Co-design as Pedagogy:

Identifying Materiality, Designed Form, and Learning Activities with/for Visually Impaired Children

Anqi Rong

School of Architecture, Design and Planning

The University of Sydney

*This thesis is submitted to fulfil requirements for
the degree of Doctor of Philosophy
June 2025*

Co-design as Pedagogy:
Identifying Materiality, Designed Form, and Learning Activities with/for Visually Impaired Children

by **Anqi Rong**

26 June 2025

Supervisor: Dr Nina Edward
Co-Supervisor: Dr Leigh-Anne Hepburn

Design Lab
School of Architecture, Design and Planning
The University of Sydney

Abstract

This research bridges the fields of design and education, scrutinising the hurdles that developing countries—China in particular—face when crafting high-quality pedagogical resources for visually impaired children. While inclusive design principles for children with special needs are widely accepted, the methods and effectiveness of these approaches remain contentious. Scholars and practitioners disagree on how inclusive design ideals should be translated into classroom artefacts. One camp promotes “universal” solutions that can be mass-produced for all learners, while another argues for highly customised, impairment-specific tools. Each approach raises practical questions about cost, scalability, and cultural relevance. Underlying both controversies is a consistent resource gap. Design guidelines emphasise personalised support, yet many schools lack the specialised expertise, tactile materials, and structured multisensory activities needed to enact those guidelines. As a result, the promise of inclusivity often remains aspirational, leaving visually impaired children with fragmented or insufficient learning experiences.

This study focuses on two main challenges in understanding the learning activities of visually impaired children: first, identifying the key elements—humans and materials; and second, understanding how their nature and configuration contribute to the learning activity. That is, the central aim of the research is to analyse and collaboratively design complex learning activities that integrate people, materials, and pedagogical design.

Cultural-Historical Activity Theory is employed as the theoretical framework, highlighting that learning is a collaborative process, shaped by a shared object of learning and influenced by participants’ intrapersonal experiences within their broader sociocultural context. The research adopts a case study methodology, with data collected through interviews, instructional observations, prototyping, documents, and collaborative workshops. The study involved 27 visually impaired children, 8 teachers, and 3 experts, with 89 days of classroom routines observed.

The findings reveal how teachers conceptualise and implement design strategies through multiple interactive layers—individual, team, community, social and institutional. Furthermore, the research identifies the central role materials play, demonstrating their influence on interactions, meaning-making, and emergent systemic wholeness within learning activities. It also elucidates how designers act as crucial negotiators, mediating roles, power dynamics, and relationships among stakeholders. Finally, the thesis identifies six core features (role shifts, sociomateriality, generativity, self-reliance, divergence, and fluid hierarchies) of co-design processes with visually impaired children, emphasising that expanding learning itself can be a key outcome of collaborative design.

Throughout, I argue that co-design can be used as a method to actively include visually impaired children in practising their learning to the context, emphasising the importance of the relations and socio-material arrangements that structure these design practices. As such, this thesis contributes primarily to the research on collaborative design and learning design that have implications for designers and educators who wish to engage in shaping inclusive activities for learning.

Keywords: Design for Learning, Materiality, Co-design, Learning Activity, Visually Impaired Children, Cultural-Historical Activity Theory, Interdisciplinary Collaboration, Pedagogical Design

Acknowledgments

I have pictured this moment countless times, wondering where I would be, and whether the act of writing these lines would bring quiet tears or irrepressible excitement. Yet now, as I finally lay pen to paper, words come slowly. The hesitation is not lack of gratitude but a surfeit of it: so many people to honour, so many unforgettable moments to preserve, and the fear that any sentence might omit a kindness or, in trying to name them all, over-embroider the page.

I am thirty-three this year. My doctoral journey began in the spring of 2022 and concludes in the summer of 2025. In between I have lived through a global pandemic, pregnancy, quarantine, childbirth, a university transfer, and the long suspense of visa approvals—ordinary doctoral days marked by extraordinary events.

Good fortune lies in the people we meet, and the generosity of my teachers is measureless. My deepest thanks go to Dr Nina Hansopaheluwakan Edward and Dr Leigh-Anne Hepburn for granting me a scholarly home rich in freedom and trust, where exploration could blossom into growth. I am equally grateful to everyone whose paths have crossed mine and sparked inspiration along the way. Dr Dian Li guided my earliest steps in this research. Dr Eugenia Gasparri offered timely academic support, while Dr Chirag Deb, Dr Bow Wu, and Dr Enya Moore provided valuable suggestions in the final stages of the thesis. I also treasure the counsel I received at Leeds from Dr Jeanne-Louise Moys, Dr Rui Leitão, and Dr Francisco Queiroz.

My heartfelt appreciation belongs to my family, my husband, my daughter, and my son, whose love steadied every stride of this journey.

And, I thank myself who rose after the children fell asleep, night after night—one thousand nights of study and resolve—for carrying this dream to the page.

Table of Contents

List of Figures

List of Tables

Statement of Originality

This is to certify that to the best of my knowledge, the content of this thesis is my own work. This thesis has not been submitted for any degree or other purposes.

I confirm that no generative artificial intelligence tools were used at any stage in the research, writing, or analysis of this thesis. I further certify that the intellectual content of this thesis is the product of my own work and that all the assistance received in preparing this thesis and sources have been acknowledged.

Signature:

Anqi Rong
Date: 10 July 2025

List of Publications

The following works were published during my PhD candidature and some are referred to within the thesis.
* Those marked with an asterisk have been included as chapters herein and in line with the University of Sydney guidelines for "Theses including publications".[1]

Journal Papers

Rong, A., Hansopaheluwakan-Edward, N., & Li, D. (2023). Analyzing the color availability of AI-generated posters based on K-means clustering: 74% orange, 38% cyan, 32% yellow, and 28% blue-cyan. *Color Research & Application*, 49(2), 234-257.
DOI: https://doi.org/10.1002/col.22912

Rong, A., Hansopaheluwakan-Edward, N., & Li, D. (2024). From vulnerability to accessibility, and expansion possibilities: A systematic review, meta-analysis, and implications of information design for vulnerable populations. *Information Design Journal*.
DOI: https://doi.org/10.1075/idj.23011.ron

*__Rong, A.,__ Hansopaheluwakan-Edward, N., & Li, D. (2025). Visualizing invisible information: A scoping review of present findings, challenges and opportunities on tactile graphics design. *Visual Communication*. DOI: https://doi.org/10.1177/14703572241300884

*__Rong, A.__ & Hansopaheluwakan-Edward, N. (2025). Uncovering facilitators and constraints in co-design with visually impaired children: A sociomateriality perspective. *The Design Journal*. DOI: https://doi.org/10.1080/14606925.2025.2477929

*__Rong, A.,__ Xu, J., Gao, H., Lin, Z., & Wei, W. (2024). Experience as it is experienced: Effectiveness of Sensory Integration Based Multi-sensory Books Design Centered on the Experience of Visually Impaired Students. *International Journal of Disability Development and Education*. (Under Review)

*__Rong, A.__ & Hansopaheluwakan-Edward, N. (2025). Invisible Visual Arts Education. *Exceptional Children*. (Under Review)

*__Rong, A.__ & Hansopaheluwakan-Edward, N. (2025). Co-design as Pedagogy: Understanding Materiality, Designed Form and Learning Activity with/for Visually Impaired Children. *Co-design*. (Under Review)

Rong, A. & Cong, Z. (2025). Homophonic Archive and Polyphonic Design: Dialogue with Rural China. *Design Issues*. (Under Review)

[1] https://www.sydney.edu.au/students/hdr-research-skills/theses-including-publications.html

Conference Papers

Rong, A. & Hansopaheluwakan-Edward, N. (2023). A bibliometric analysis of research trends and advanced technologies in tactile graphics design. In *15th International Conference of the European Academy of Design*.
DOI: https://doi.org/10.5151/ead2023-1BIL-01Full-06Rong

Rong, A., & Li, G. (2023). Visually Impaired Children with Special Educational Needs: Identifying Suitable Tactile Graphics Learning Materials. In *SHS Web of Conferences* (Vol. 174, p. 01003). EDP Sciences. DOI: https://doi.org/10.1051/shsconf/202317401003

Rong, A., & Li, G. (2023, December). Integrating Artificial Intelligence in Design: An Exploration of ChatGPT's Role in Inclusive Design Research. In *2023 5th International Conference on Literature, Art and Human Development* (ICLAHD 2023) (pp. 910-924). Atlantis Press. DOI: https://doi.org/10.2991/978-2-38476-170-8_101

Rong, A. & Hansopaheluwakan-Edward, N. (2025). Sociology through/with design: Embedding Social Justice into Design Pedagogy. In 2025 *Design Research Society (DRS) Special Interest Group (EdSIG) LearnXDesign conference*. (Accept)

***Rong, A**. & Hansopaheluwakan-Edward, N. (2025). Who Designs, Who Teaches, Who Knows? Negotiating Co-Creation with Visually Impaired Children. In *International Association of Societies of Design Research IASDR 2025*. (Accept)

Chinese Journal Papers

Rong, A., & Bao, G. (2024). Strategies and Methods of Tactile Graphics Design for Visually Impaired People. Design Research, 14(04):26-30+41.

Rong, A., & Li, G. (2024). Decoding Color: Analyzing the Multidimensional Choices of Color Models for Digital Image Processing. Color, 02: 59-62.

Li, G., & **Rong, A.** (2024). Inclusive Perspective: Expanding the Desirability Dimension of User Experience in Inclusive Design. Design Research, 14(03), 20-24.

Authorship Attribution Statement

The publications listed below have been included in this thesis within separate chapters. More detailed authorship attribution statements are provided below.

Rong, A., Hansopaheluwakan-Edward, N., & Li, D. (2025). Visualizing invisible information: A scoping review of present findings, challenges and opportunities on tactile graphics design. *Visual Communication*.

I led the review, analysis and writing of the paper. Edward and Li provided oversight, feedback, ongoing guidance and contributed to data analysis.

Rong, A. & Hansopaheluwakan-Edward, N. (2025). Uncovering facilitators and constraints in co-design with visually impaired children: A sociomateriality perspective. *The Design Journal*.

I led the data collection, data analysis and writing of the paper. Edward provided oversight, feedback and ongoing guidance.

Rong, A. & Hansopaheluwakan-Edward, N. (submitted). *Invisible Visual Arts Education. Exceptional Children*.

I led the data collection, data analysis and writing of the paper. Edward provided oversight, feedback and ongoing guidance.

Rong, A., Xu, J., Gao, H., Lin, Z., & Wei, W. (submitted). Experience as it is experienced: Effectiveness of Sensory Integration Based Multi-sensory Books Design Centered on the Experience of Visually Impaired Students. *International Journal of Disability Development and Education*.

I led the data analysis and writing of the paper. Xu, Gao, Lin and Wei collected the data. Xu provided oversight, feedback and contributed to data analysis.

Rong, A. & Hansopaheluwakan-Edward, N. (submitted). Co-design as Pedagogy: Understanding Materiality, Designed Form and Learning Activity with/for Visually Impaired Children. *Co-design*.

I led the data collection, data analysis and writing of the paper. Edward provided oversight, feedback and ongoing guidance.

Rong, A. & Hansopaheluwakan-Edward, N. (2025). Who Designs, Who Teaches, Who Knows? Negotiating Co-Creation with Visually Impaired Children. In *International Association of Societies of Design Research IASDR 2025*.

I led the data collection, data analysis and writing of the paper. Edward provided oversight, feedback and ongoing guidance.

As supervisor for the candidature upon which this thesis is based, I can confirm that the authorship attribution statements above are correct.

Signature:

Anqi Rong
Date: 10 July 2025

Supervisor Name: Dr Nina Hansopaheluwakan Edward

Signature:

Date: 10 July 2025

List of Abbreviations

CwD	Children with Disabilities
VIC	Visually Impaired Children
TVI	Teacher of Students with Visual Impairments
RNIB	Royal National Institute of Blind People
BANA	Braille Authority of North America
US	United States
UK	United Kingdom
SASSVI	South Australian School and Services for Vision Impaired
CHAT	Cultural Historical Activity Theory
PVI	People with Visual Impairments
O&M	Orientation and Mobility
AR	Augmented Reality
TG	Tactile Graphics
HCI	Human-Computer Interaction

Glossary of Terms

Co-Design	A collaborative design methodology that foregrounds the active involvement of stakeholders, including children, educators, and designers throughout the design process. In this thesis, co-design is positioned as both a methodology and a pedagogy that reconfigures traditional power structures, inviting VIC into the role of design participants. It emphasises shared agency, situated knowledge, and the mutual shaping of educational environments.
Tactile Graphics	Raised representations of visual information—such as diagrams, maps, and illustrations—designed for exploration through touch by individuals with visual impairments. TG serve both communicative and educational functions, allowing users to access and interpret spatial, conceptual, and symbolic information. In this research, TG are not just end-products but also sites of co-design, learning, and negotiation.
Visually Impaired Children	Children with varying degrees of visual impairment, ranging from low vision to total blindness.
Teacher of Students with Visual Impairments	A professional specialised in instructing and supporting visually impaired students. TVIs play a crucial role in adapting materials, scaffolding learning, and facilitating access to curriculum content.
Materials	Materials are conceptualised not merely as inert physical substances or static educational tools, but as dynamic, agentive participants in learning activities. They possess affordances, sensory properties, and symbolic potentials that actively shape interaction, meaning-making, and the development of knowledge.
Materiality	The physical, sensory, and symbolic qualities of materials and how these characteristics afford or constrain certain types of learning and interaction. Materiality is treated in this thesis as both a tangible property and an interpretive concept that shapes meaning-making processes in educational contexts.
Sociomateriality	A theoretical perspective that recognises the inseparability of social and material dimensions in shaping human activity. This concept frames how artefacts, bodies, environments, and practices are entangled in co-constitutive relationships. In the thesis, sociomateriality is used to understand how learning is configured through the dynamic interplay between people, materials, and pedagogical structures.
Cultural-Historical Activity Theory	A theoretical framework originating from Vygotskian psychology that emphasises learning as a mediated, culturally situated activity

system. This thesis draws on third-generation CHAT to examine the tensions, contradictions, and multi-actor dynamics that emerge in co-design practices with VIC, particularly regarding roles, tools, rules, and communities.

Design for Learning A paradigm that recognises that learning environments, tools, and interactions can be intentionally designed to foster knowledge construction. Design for learning acknowledges both planned (designed-in) and emergent (learner-generated) outcomes, aligning closely with co-design in educational contexts.

Design Thinking An iterative approach to problem-solving that draws on empathy, creativity, prototyping, and testing. Within the thesis, design thinking is examined both as a methodology used by professional designers and as a pedagogical practice that can be cultivated among non-designers, including VIC and teachers.

Fluid Hierarchies A concept introduced in the thesis to describe the shifting power dynamics in co-design settings where traditional hierarchies between adult and child, expert and novice, designer and user become reconfigured. Fluid hierarchies promote shared decision-making and support inclusive participation.

Design for Orchestration A concept drawn from Dillenbourg (2013) that refers to teachers' dynamic coordination of tools, tasks, and social configurations in real-time. It is likened to improvisational performance, where responsiveness and adaptability are central to supporting learning in complex environments.

Learning Activity A structured yet evolving system of goal-oriented action mediated by tools, shaped by community rules, and oriented toward a shared object. In this thesis, learning activities are seen as emergent, materially mediated practices where knowledge is co-constructed.

Expansive Learning A form of learning that transcends the acquisition of predefined knowledge, involving the transformation of the object of activity itself. Derived from CHAT, expansive learning describes how participants redefine problems, roles, and outcomes through cycles of questioning, modeling, and implementing new practices.

Contradiction Systemic tensions or misalignments within or between components of an activity system (e.g., between tools and rules, or between roles and goals). These contradictions are seen as drivers of change and innovation.

Historicity The recognition that all practices, tools, and relationships are shaped by their developmental trajectories. In this thesis, historicity underscores how past educational practices,

	institutional policies, and material conventions influence the present.
Division of Labour	The ways in which roles and responsibilities are distributed in an activity system. This thesis explores how formal and informal role divisions among teachers, designers, and VIC shape the co-design process and learning outcomes.
Object	The shared goal or problem space that motivates collective activity. In this research, the object shifts from designing tactile learning materials to fostering inclusive and transformative learning environments.

1. Introduction

This chapter outlines the rationale behind the study by first examining the obstacles visually impaired children face when engaging with educational materials in their daily lives. Through an analysis of these instructional design issues and their underlying causes, the central research question emerges. The chapter concludes by defining the investigation's scope and presenting the thesis's overall structure.

1.1 Motivation

Design for disability has gained significant recognition as a crucial area of study, emphasising the need for inclusive practices that accommodate diverse user needs. Achieving such inclusivity requires the active participation of people with disabilities in design processes is essential (Watchorn et al., 2024). Co-design is increasingly employed in disability research and project work as an essential component of ethical and respectful work grounded in human rights (Fraser-Barbour et al., 2023); it is particularly evident in work with populations experiencing vulnerabilities due to social, economic, and environmental barriers, from children, through to older adults (Moll et al., 2020). In educational contexts, co-design is used to create curriculum materials, learning environments, and technologies that better serve diverse students, including those with disabilities. Specifically, co-design is a promising method for overcoming design hurdles while empowering children with disabilities (CwD) through their inclusion in design projects. However, when co-designing with vulnerable groups, there is often reluctance to generalise best practices due to participants' diverse and unique needs (Hodson et al., 2023). Moreover, these settings can be unfamiliar and challenging for researchers who lack experience working with individuals with impairments (Rajapakse et al., 2021).

One of the main threads of recent research on co-design with CwD is the notion of 'participation' as a tool for empowering children (Raman & French, 2022); the other is the desire to 'create' something and make it actionable (whether it is a product, a space or a curriculum) (Bolster et al., 2021; Magkafa et al., 2021). Despite these insights, empirical research on co-design with CwD, particularly with visually impaired children (VIC), remains limited. Co-designing with VIC presents unique challenges, including the need for specialised communication methods and materials, which adds complexity to the process.

In today's digital age, much information is presented visually, with graphical representations becoming increasingly prevalent. Graphics are usually accessed visually by sighted individuals, but person with visual impairments (PVI)—who depend on touch—often cannot decode these images, which limits their capacity to interact fully with their surroundings. The ability to interpret graphical content is especially important for children learning subjects such as art, technology, mathematics, and science. Consequently, it is vital to develop this skill early in life (for statistical purposes, the United Nations—without prejudice to any other Member State definitions—classifies 'youth' as those aged 15 to 24 years). Hence, the principal issue is how to design learning materials for VIC in school to let them acquire and understand this skill as early as possible. Globally, a range of practices and principles have been developed to create effective tactile materials for educational purposes (Park & Hong, 2023). However, the challenge lies in adapting these practices to local educational contexts. In China, where educational approaches and cultural frameworks differ from those of other regions, there is a pressing need to understand how global practices in tactile graphic design can be effectively tailored to meet the specific learning needs and conditions of VIC.

The changing landscape of special education in China

> "How to help special children, whether to follow the path of special education or the path of general education, we are very unclear and don't know what to do."
>
> \- A special education teacher in China

In recent years, China has made significant strides in ensuring equal access to education for persons with disabilities, including those who are visually impaired, through comprehensive legal and policy measures. The concept of “prohibiting discrimination in education on the basis of disability” has permeated the Law of the People’s Republic of China on Higher Education, the Law of the People’s Republic of China on the Protection of Persons with Disabilities, and the Regulations on the Education of Persons with Disabilities. Since the 1980s, the educational system for students with disabilities has undergone substantial development, expanding from a few specialised institutions to numerous specialisations and educational facilities. This progress has enabled a growing number of students with disabilities to attend both mainstream universities and dedicated special education schools.

Despite these legal and structural advancements, the Chinese educational system remains fundamentally “ill-equipped” to meet the rigorous demands of inclusive pedagogy, especially for VIC. This deficit is three-fold. First, resources are unevenly distributed: specialist expertise (e.g., teachers of the visually impaired, orientation and mobility support, occupational therapy) is concentrated in major cities, while the cost and labour of procuring or producing high-quality tactile and large-print materials frequently fall on individual schools and families, entrenching inequity. Second, an examination-oriented pedagogical culture privileges rote memorisation and standardised testing over adaptive (Wang & McLaughlin, 2024), inquiry-driven learning, leaving few robust curricular routines for translating complex visual content into accessible non-visual and tactile modalities—skills that are foundational for VIC. Thirdly, the process of teaching and learning is undermined by the absence of systematic, research-informed design methodologies. While teachers may devise ad-hoc resources, these efforts are typically isolated, undocumented, and non-scalable, demonstrating a profound lack of a cohesive, collaborative framework—like co-design—to institutionalise and professionalise inclusive material creation (Rong et al., 2025). This intersection of systemic resource deficits, unsuitable pedagogy, and methodological gaps establishes the urgent need for a transformative intervention that can empower local practitioners.

A notable milestone occurred in 2014 when, for the first time, a visually impaired student applied to take the *Gaokao*, China's university entrance examination. Despite such advancements, the 2019 yearbook data from the Chinese Ministry of Education reveal that out of a total population of 277 million children, only approximately 40,000 (0.014%) with visual disabilities are integrated into the national education system. The majority of visually impaired individuals in China still face significant barriers to accessing compulsory education due to their disabilities, transportation challenges, and economic constraints. These barriers have profound implications not only for the individuals affected but also for society and the country as a whole. Although visual impairment is gaining more attention in China, the sector continues to grapple with issues related to both participation and the quality of educational provision.

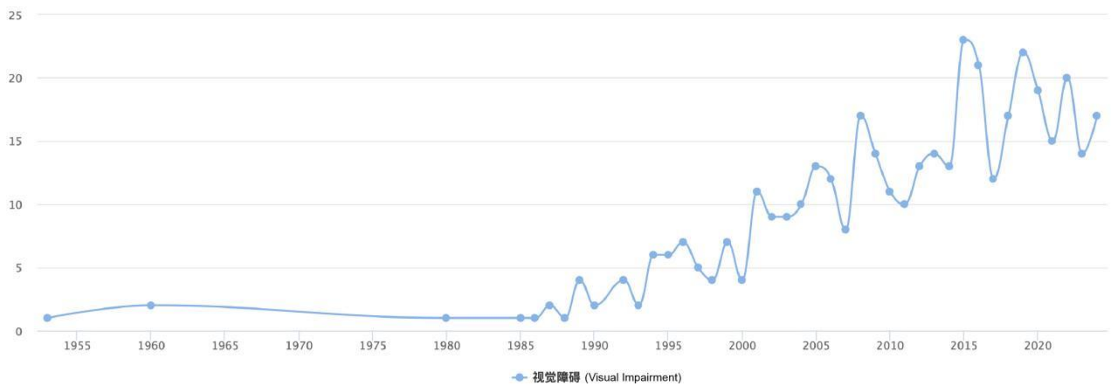

Figure 1.1.Attention index analysis (scope of search: source databases, including journal repositories, doctoral thesis repositories, master's thesis repositories, newspaper repositories, conference repositories).

Furthermore, a review of research outputs highlights a glaring gap in empirical studies on visual impairment within China. Data from the Chinese National Knowledge Infrastructure (CNKI), the largest literature database in the country, indicate a minimal number of studies focused on visual impairment (Figure 1.1), contrasting sharply with the broader coverage observed in international databases like Scopus

(Figure 1.2). This discrepancy underscores the urgent need for more targeted research in this field to inform policy and practice, thereby enhancing the educational experiences and outcomes for VIC in China.

Year ↓	Documents ↑
2025	207
2024	7918
2023	7320
2022	7365
2021	7162
2020	6036
2019	5366
2018	5029
2017	4619

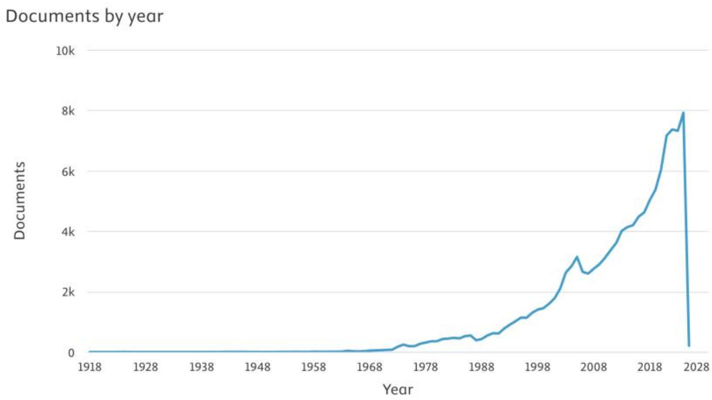

Figure 1.2.Scopus search results: TITLE-ABS-KEY (visual impairment).

Co-Design with VIC: importance, needs and challenges

Extensive work has investigated how co-design affects children, covering topics such as their empowerment (Iversen et al., 2017) and the pedagogical gains it can bring (Barendregt et al., 2016). Scholars increasingly acknowledge that engaging children in the co-design process uncovers valuable insights rooted in their unique viewpoints (Hemmert et al., 2010). However, collaborating with children becomes markedly more complex when cultural, linguistic, or contextual barriers are at play (Hijab et al., 2024). Notably, conventional co-design and participatory design approaches are not intrinsically unsuitable for use with visually impaired participants (Magnusson et al., 2017).

From a design perspective, designers need substantial expertise and resources to adapt the standard design tools for non-visual use, ensuring that all VIC can engage meaningfully in the design process. From an educational standpoint, integrating co-design into existing curricula and pedagogical frameworks can be complex. Teachers may require training and support to facilitate the co-design process effectively, ensuring that it complements rather than disrupts traditional teaching methods. Moreover, balancing the creative input of children with educational objectives necessitates a delicate negotiation of roles and expectations among educators, designers, and children. These challenges highlight the need for ongoing collaboration, interdisciplinary training, and supportive policies to successfully implement co-design practices that truly benefit VIC in China's educational landscape.

Researcher personal motivation

I write as a Chinese designer-researcher educated across Australia, the United States, and the United Kingdom, working bilingually between Chinese and English design and education communities. Early exposure to mature inclusion ecosystems—through collaborations and consultations with organisations such as the Royal National Institute of Blind People (RNIB) and the Braille Authority of North America (BANA)—was formative: it demonstrated how accessible materials, standards, and professional networks can tangibly expand learners' participation. At the same time, returning to Chinese school contexts revealed how such "best practices" do not simply transfer; differences in policy, resources, assessment cultures, and everyday routines reconfigure what is possible in classrooms. This insider-outsider trajectory made visible the distance between well-intentioned design solutions and the situated practices that sustain or undermine them. My motivations are also personal: as the mother of two children, I have a daily, embodied sense of how educational environments, materials, and routines scaffold (or foreclose) participation, confidence, and belonging. This lived perspective sharpened my interest in learners whose access is most mediated by material design, and led me to focus on VIC.

The choice of VIC is both pragmatic and ethical. Globally, visual impairment remains a significant yet unevenly addressed public health and educational concern; international evidence highlights persistent barriers to participation that hinge on the availability and design of accessible materials, assistive technologies, and school-level supports (WHO, 2019). The challenge is not merely technical (e.g., producing tactile aids) but conceptual and pedagogical—how teachers, children, and designers co-construct learning activities when information must be apprehended haptically, aurally, and through embodied routines. Encounters with teachers and families underscored the limits of my prior “designer’s mindset,” which too readily equated ingenuity with improvement. This project therefore proceeds from the view that improving inclusion is not a matter of importing “good” design solutions, but of cultivating locally workable forms of co-design as pedagogy within the constraints and possibilities of particular settings.

1.2 Context

> “[A] crucial aspect of human mastery...is the creation and use of auxiliary or “artificial” stimuli; through such stimuli an immediate situation and reaction linked to it are altered by active human intervention” (Vygotsky, 1978, p. 123).

How do we think about the materials? How do the materials we use shape learning activity? Can we achieve greater educational benefits with fewer resources? What practices do the materials of our learning activities support, and how can we envision their potential for future educational environments? Moreover, considering the complex relationships between people and materials, what limitations do designers and educators impose on repurposing these materials to meet diverse learning needs?

Materials, practices, and action

The challenge of comprehending the interactions between materials and actions is longstanding. This challenge is partly rooted in the broader theoretical discourse on the relationship between structure and agency (Bourdieu,1977; Simmel, 1909). Typically, this discourse focuses on human actions within social structures rather than the physical structures that constitute our learning activities.

Shove et al. (2012) argue that studying practice allows researchers to transcend the dualisms of agency versus structure and determinism versus voluntarism. By de-emphasising human agency and choice, the study of practice enables the conceptualisation of stability without attributing it to fixed structures. Building on Giddens' theory of structuration, which posits that the day-to-day activities of social actors draw upon and reproduce the structural features of broader social systems (Giddens, 1984), Shove et al. (2012) seek to describe how practices emerge, evolve, and disappear.

They have developed a theory of social practice that views practice as an entity comprising three elements: *competence, meaning*, and *materials*; and as performance, the enactment of these elements in activity over time. By tracing the interactions among these three elements, they map changes in practice in a manner that avoids both social and material determinism. This approach allows for a nuanced understanding of how practices are maintained and transformed, highlighting the dynamic interplay between human actions and the material contexts in which they occur.

Our perceptions of materials are deeply influenced by socio-cultural contexts. Estrid Sørensen (2009) posits that addressing these questions is essential not only for understanding how materials contribute to teaching and learning practices but also for recognising the consequences of failing to broaden the research agenda. Sørensen critiques the prevalent humanist approaches in educational research for their neglect of material considerations. She advocates for a post-humanist reframing that integrates both the social and material dimensions of learning. This perspective emphasises that materials should not be viewed merely as tools for educational purposes, detached from the humans who interact with them.

How we think about materials is not only reflected in how we name them, but in our actions. Recent initiatives demonstrate a collective aspiration to transform educational futures through thoughtfully designed actions—the Perkins School for the Blind in the US and the South Australian School and Services for the Visually Impaired (SASSVI) in Australia exemplify this commitment. These institutions share a fundamental belief that enhancing the built environment can significantly improve educational outcomes, driven by broader educational and social motivations. Specifically, At Perkins, teachers routinely convert mainstream worksheets into tactile formats through a curated Tactile Graphics Library that provides PIAF/Swell-paper ready diagrams and paired lesson ideas, operationalising "materials" as instructional mediators rather than neutral carriers of content (e.g., raised-line overlays, simplified backgrounds, braille labelling) (Perkins School for the Blind, 2025a). Campus-based orientation and mobility (O&M) instruction similarly choreographs learners, routes and built cues (handrails, door hardware, surface changes) into personalised travel plans, with techniques (e.g., sound cues at thresholds, constant-contact cane) iteratively adapted to students' profiles and Individual Education Plans—again treating the environment as part of the pedagogical apparatus (Perkins School for the Blind, 2025b). SASSVI embeds similar pragmatics system-wide: advisory teachers co-design access plans with schools, adapt learning materials, deploy access technologies, and coordinate access-format production, coupling curricular adaptation with material translation at scale (SASSVI, 2025). These school-level practices are underwritten by statewide design standards that specify wayfinding and surface cues (e.g., tactile ground surface indicators with minimum luminance contrast thresholds), logical pathways, circular layouts to reduce travel distances, and indoor-outdoor continuity to support supervision and independence, demonstrating how policy-level material prescriptions ramify into everyday learning activity (South Australian Department for Education, 2025a; 2025b).

Materials for learning have been central to studies aiming to increase educational efficiencies and facilitate personalised learning. However, many of these studies overlook how materials inherently alter learning activities from an ecological or systemic perspective. By starting with pre-assumed needs and measuring outcomes based on these assumptions, such studies reinforce the entrenched notion that learning is solely an individual, cognitive achievement (Létourneau et al., 2025; Masiello et al., 2024; Sweller, 2024). Contemporary theorists have argued for a broader understanding of learning as a social and context-sensitive process (Lave & Wenger, 1991; Wenger, 1999). Despite this shift, the concept of materiality remains underdeveloped. To advance the field, it is imperative to not only incorporate material dimensions but also to fundamentally rethink our approaches to learning and its study.

Design, learning, and design for learning

Our understanding of how we learn necessitates a redefinition of what it means to design for learning. Goodyear and Carvalho (2014) assert that learning can be both intentional and incidental, arising directly or indirectly from participation in formal studies or informal activities. Consequently, learning can be characterised as persistent change resulting from organised education as well as from navigating the world independently. To advance the objectives of this thesis, I chose to rely on the work of Tim Ingold to define my thinking on learning.

In exploring a world where objects are more than mere means to an end, Ingold (2012) advocates for a fundamentally new theory of life. He argues that matter should not be perceived as inanimate raw material awaiting transformation but as processes of flow and change. Ingold envisions things as dynamic assemblies of materials in motion, distinct from static objects that impede movement; and where the body as a dynamic centre of unfolding activity, rather than a passive recipient of accumulated practices.

This perspective raises critical questions about design and the role of designers. For the sake of simplicity, I will start with the Oxford English Dictionary, design is defined as “a plan or drawing produced to show the look and function or workings of a building, garment, or other object before it is built or made." Contrasting this with Ingold's worldview, a tension emerges: traditional design is viewed as a mental process involving action upon the world, rather than a process of correspondence (Ingold, 2013). Therefore, I argue for a reconceptualisation of design for learning that integrates both representational and non-representational approaches to thinking and practice.

"Design in advance" is the conventional instructional design practices familiar to teachers and designers. This approach involves designing elements that can be altered, such as tasks, tools, and the social configurations of co-design. However, it does not encompass the design of learning activities themselves, as learners' actions are influenced by numerous factors beyond direct design control. Another approach, "design for orchestration" (Dillenbourg, 2013), emphasises adaptive responsiveness to the tools, tasks, and learners present on any given day. This method is akin to improvisational jazz, prioritising flexibility over rigid composition. In the *Literature Review*, I will explore correspondence in greater detail, highlighting several productive strategies that utilise this type of design orchestration.

1.3 The study

In this thesis, I adopt Sanders and Stappers's (2008) definition of co-design, which emphasises that co-design "will change how we design, what we design, and who designs. It will also affect the tools and methods that the new teams of co-designers will use." According to Sanders and Stappers, the designer's role shifts from that of a detached observer to an embedded collaborator alongside participants. Complementing this view, Kleinsmann and Valkenburg (2008) define co-design as "the process in which actors from different disciplines share their knowledge about both the design process and the design content...in order to create shared understanding on both aspects...and to achieve the larger common objective: the new product to be designed." This framing highlights the centrality of knowledge exchange and mutual comprehension (Steen, 2013), which this research prioritises. I propose that co-design can be conceptualised and organised as a collaborative design-thinking process—or, following Fischer et al. (2021), as a learning journey.

My focus is not solely on design practices but on how materials are integrated into these practices (Sørensen, 2009). What is more, I am concerned with what can be said about how materials, designed forms—can be said to influence learning activity. This work therefore sits at the nexus of three domains: co-design (the processes and influences on design decisions), quality materials (the "what" of design and its role in learning), and educational enhancement (strategies to improve learning for VIC) (Figure 1.3). To the best of my knowledge, this is the first empirical study to unite these core facets of co-design—what, how, why, and who—within a single project focused on VIC in China.

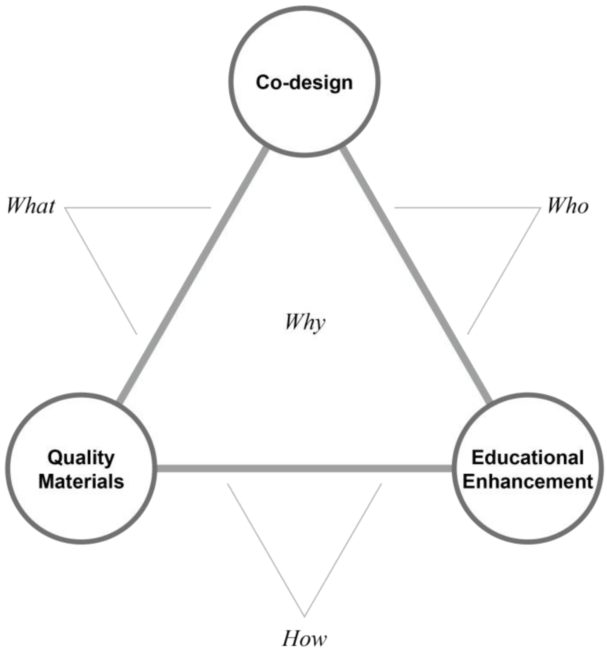

Figure 1.3. Intersection of the study's core domains.

Research aims

In China, educational practices are profoundly influenced by cultural norms and institutional structures, presenting a unique opportunity to investigate how design practices can transform the learning experiences of VIC. The co-design process, situated within this cultural and educational context, has the potential to dismantle barriers to inclusion and foster more engaging and effective learning activities. However, the challenge extends beyond merely creating accessible materials; it involves reimagining the very forms these materials take and evaluating how they facilitate or impede interaction, meaning-making, and learning outcomes. This thesis, therefore, seeks to bridge the gap between design theory, pedagogy, and the lived experiences of VIC in China, contributing to a broader understanding of how co-design can be a transformative pedagogical tool.

Through this research, I aim to offer insights that can empower designers and educators to rethink how educational experiences are crafted and how children, particularly those with disabilities, can be seen as active participants in shaping their own learning journeys. I ask how learning materials have been used as resources to support understanding in the past, and how their use could be more meaningful in the future. This study investigates how co-design can be used as a method to actively include VIC in practising their learning to the context. It further investigates how interdisciplinary collaborative design might shape VIC learning outcomes and inform future practice.

Research questions

To achieve these aims, the study addresses the following research questions:

RQ 1: How do teachers conceptualise and implement design strategies in developing learning materials and activities for visually impaired children?

RQ 2: How do materials shape learning activities for visually impaired children, and how do their properties influence interaction, meaning-making, and learning outcomes?

RQ 3: How do designers negotiate the roles, relationships, and power dynamics between materials, teachers, and visually impaired children during the co-design?

RQ 4: What are the key features of the co-design process involving visually impaired children?

Research approaches

This study is framed—and its findings interpreted—through Engeström's Cultural Historical Activity Theory (CHAT) (1987, 2001, 2008) as its principal theoretical lens. CHAT provides a socio-cultural lens for analysing collective, goal-oriented activity. In third-generation CHAT (Engeström, 2001), the basic unit of analysis is an activity system comprising subject, object, mediating artefacts, rules, community, and division of labour, oriented toward outcomes. Transformation is driven by contradictions, historically accumulated structural tensions within and between elements, and often unfolds as expansive learning, where participants reconceptualise the object and develop new practices (Engeström, 1987, 2001; Engeström & Sannino, 2010). As detailed in Chapter 3, CHAT enables a holistic examination of the intricate relationships, processes, and contributions arising when designers and teachers collaborate. Its emphasis on socio-cultural dimensions of learning design—rules, tools (artifacts), and community—illuminates how these factors shape stakeholder decisions. To deepen interpretation, CHAT is paired with design-for-learning theories and the requisite knowledge and skills drawn from established design domains (e.g., graphic design, inclusive design, product design, architecture). A case-study methodology was adopted to answer the research questions, drawing on multiple data sources at various stages—including interviews, observations, document analysis, prototyping, and workshops—for an in-depth investigation. The research process was gradual. Instead of initiating the workshops immediately, I first engaged with teachers, experts, and VIC in the early stages to accumulate experience through interviews and observational data.

1.4 Significance

I borrow the CO-DESIGN framework proposed by Schwoerer et al. (2022) that contains eight elements, each of which co-designs a salient process or product of research and/or practice to illustrate the significance of this research.

(C) **Co-production of knowledge**: This thesis exemplifies the co-production of knowledge by actively involving VIC, educators, and designer in the research process.

(O) **Open science**: Embracing the principles of open science (Fecher & Friesike, 2014), this research promotes transparency and accessibility in its methodologies and findings. By openly sharing data, design prototypes, and research outcomes through publications, and presentations, the thesis contributes to a broader dissemination of knowledge.

(D) **Developmental and comparative perspectives:** A wider-angle view of the world is essential for design theory in developed and developing contexts alike. The thesis adopts both developmental and comparative perspectives to contextualise its findings within the broader landscape of education. By examining the evolution of design practices for VIC in China and comparing them with international standards and approaches, the research identifies key features, challenges, and opportunities.

(E) **Equity and diversity:** By addressing the specific needs and challenges faced by VIC, the thesis advocates for design practices that accommodate diverse learning styles and abilities. This commitment to equity ensures that the resulting educational materials and strategies are accessible to all children, regardless of their visual impairment, thereby contributing to a more just and inclusive educational system.

(S) Social innovation: The thesis contributes to social innovation by introducing co-design methodology and educational practices that enhance the learning experiences of VIC. By integrating design, theory, and practice, the research proposes new ways to engage VIC in their education. These innovative approaches not only improve educational outcomes but also inspire broader societal changes towards greater inclusivity and support for individuals with disabilities.

(I) Inclusive participation: Inclusive participation is a cornerstone of this research, ensuring that all stakeholders, especially VIC, have an active role in the design and implementation of educational practices.

(G) Goal-oriented research: This thesis is characterised by its goal-oriented research approach, aimed at achieving specific, actionable outcomes that improve educational practices for VIC. By setting clear objectives—developing accessible learning materials, enhancing VIC learning, and fostering co-design processes—the research maintains a focused trajectory towards tangible improvements in special education.

(N) New possibilities (for research): This thesis opens up new possibilities for future research; it establishes a foundation for exploring interdisciplinary collaborations between design, education, and disability studies, encouraging scholars to investigate further how co-design can be leveraged to address diverse educational needs. Additionally, the research highlights emerging areas such as the integration of assistive technologies and the role of cultural factors in shaping co-design process, paving the way for subsequent studies to build upon these insights.

As mentioned, I believe the outcomes of this work are significant as they represent several novel contributions to co-design research and educational design practice, including empirical, interdisciplinary, methodological, and artefact-related advancements.

The results of this study offer concrete guidance for educators, designers, policymakers, parents, and researchers, enabling them to articulate key dimensions of design in learning environments and to make informed decisions. Drawing on these insights, special schools and related organisations can craft more effective, evidence-based pedagogical approaches, cultivate a collaborative ethos among co-design participants, and optimise their practices in line with educational objectives and available resources.

Moreover, this research illuminates the cultural dynamics and emerging shifts in co-design with VIC—areas that, until now, have not been fully explored (Magnusson et al., 2017). The findings support calls in the literature to move beyond simply creating educational products toward also developing the materials themselves and empowering the people involved, thereby laying the groundwork for a more sustainable future in education.

1.5 Structure

The remainder of this dissertation is organised into nine chapters illustrated in Figure 1.4. Chapter 2 reviews the literature relevant to this study, covering design (including pedagogy and design, design for learning, factors influencing design decisions, and design for/with VIC), the materiality of learning, and co-design, and highlights their interconnections within educational contexts.

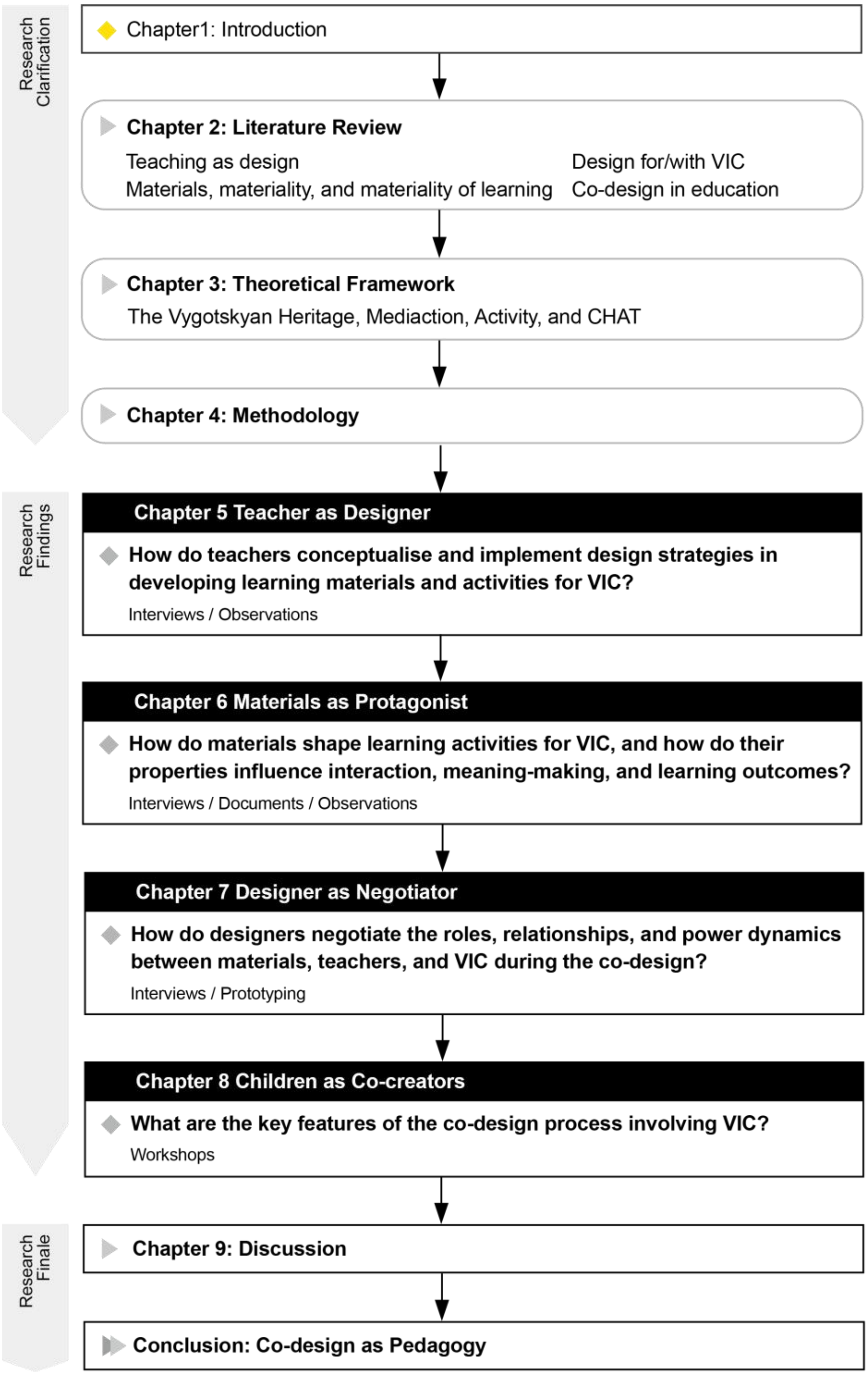

Figure 1.4. Structure of this thesis.

Chapter 3, *theoretical framework*, introduces the theoretical framework, explaining why CHAT was chosen as the guiding lens, detailing its core principles, advantages, limitations, and its multifaceted role throughout the research process.

Chapter 4, *methodology*, outlines the research methodology, describing the overall approach, recruiting strategies, data collection tools and procedures, ethical considerations, and methods for data analysis, while critically addressing issues of trustworthiness.

Chapter 5, *teaching as designer*, reconceptualizes teaching as a design practice (e.g., Eisner, 1983). It argues that, like designers, teachers interpret available resources, assess pedagogical constraints, balance trade-offs, and develop strategic designs to achieve their instructional objectives.

Chapter 6, *materials as protagonist*, describes how materials are conceptualised and reflected in learning activities. Through a critical examination of how materials mediate interaction, meaning-making, and learning outcomes, this chapter will explore the intersection of design and perception, where materials are not simply tools for knowledge transmission but co-creators in the construction of learning itself.

Chapter 7, *designer as negotiator*, this chapter positions the designer as a negotiator who navigates intersecting activity systems—teachers' pedagogical frameworks, VIC's experiential knowledge, and material possibilities. I argue that rather than designing learning materials directly, designers can help teachers identify problems with the design process and how to solve them.

Chapter 8, *Children as co-designers*, demonstrates how co-design with VIC not only advances the material outcomes but significantly enriches pedagogical approaches, thereby expanding the conceptual and practical scope of inclusive pedagogy.

Chapter 9 brings together the entire thesis, synthesising the findings from Chapters 5 through 8 into a critical discussion aimed at addressing the central research questions.

These findings are examined in relation to the existing literature and interpreted through the lens of the chosen theoretical framework and conceptual constructs.

I conclude with a Chapter 10 entitled *Co-Design as Pedagogy* to outline the key insights and highlighting the study's contributions to knowledge. It also discusses the practical implications, limitations, and broader significance of the research, and explores future directions for development and application across stakeholders and within wider educational practice.

2. Literature Review

This chapter provides a review of the literature on core areas for this research including design (pedagogy and design, design for learning, influencing factors for design decisions, design for/with PVI), materiality of learning, and co-design. It draws connections among these areas in the context of education.

This chapter is from:
Rong, A., Hansopaheluwakan-Edward, N., & Li, D. (2025). Visualizing invisible information: A scoping review of present findings, challenges and opportunities on tactile graphics design. *Visual Communication*. DOI: https://doi.org/10.1177/14703572241300884

2.1 Introduction

This chapter surveys the body of literature related to design and education for VIC, bringing together theoretical, conceptual, and empirical studies that have shaped the foundation of this PhD research. The first section examines the concept of teaching as design and the knowledge and skills necessary for effectively integrating design into teaching. It explores the factors influencing teachers' design decisions. The second section focuses on the materiality of learning, contextualising the study and offering both conceptual and practical perspectives. The third section addresses design practices for and with PVI. The final section examines co-design within educational environments, highlighting its potential to enrich participant learning. Although the collaborative and interdisciplinary nature of design is acknowledged, the review underscores a notable lack of empirical research focused on co-design in educational settings involving VIC—an area this study aims to explore.

2.2 Teaching as Design

> "This premise implies that the function of teaching is to arrange-to design and implement-a context in which learning can flourish. It implies too that the thought and action of teaching can be studied, just as are the thought and action of design, and that improvements in design teaching can be implemented and their effects assessed." (Dinham, 1989, p. 80)

The interpretation of teaching as design is a relatively recent development. Teachers must perceive and interpret available resources, assess the constraints of the classroom environment, balance competing priorities, and devise strategies—all with the goal of achieving their instructional objectives. One way to unlock the full potential of teaching as design is by reimagining traditional approaches to the design, dissemination, and utilisation of learning materials.

How teaching is design

> "Design is more than the process of creating something; it is about crafting something in order to solve a human problem, to change the state of a particular situation from a current condition to a desired one, and to accomplish a goal. I use the term "craft" because it implies a certain quality – some designs are more elegant than others. Moreover, design, like all goal-directed human activity, involves the use of tools, be they physical or cultural." (Herbel-Eisenmann et al., 2009, p. 23)

Teaching can be conceptualised as a specialised form of design, a perspective supported by various scholars in the field. Schön (1987) posits that both designing and teaching involve the pursuit or creation of order and purpose within contexts that are often ambiguous, uncertain, and fraught with value conflicts. Building on this, Dinham (1989) extends the analogy by suggesting that effective teaching, much like effective design, demands intentional decision-making, consideration of alternative methods, and strategies for addressing challenges. He underscores the inherent complexity and integrative nature of both practices. Designers regularly navigate multiple variables, reconcile opposing priorities, and operate within constraints—acknowledging that while some outcomes may be more effective, there are rarely absolute solutions. In much the same way, teachers balance diverse factors, manage tensions, and work within limitations, where achieving optimal learning outcomes often requires adaptable and context-sensitive approaches rather than one definitive answer.

Herbel-Eisenmann et al. (2009) expand on this idea by illustrating that when teachers utilise learning materials to construct instructional episodes aimed at achieving specific goals, they are inherently engaging in design activities. This occurs regardless of whether the teachers explicitly intend to design the learning experience; whether teachers modify existing materials or apply them in a straightforward manner, they are engaging in a goal-directed process that can be considered design.

The application of the design metaphor to teaching is particularly valuable as it underscores the dynamic interaction between teachers (agents) and learning materials (tools). This interplay shapes the instructional outcome. Goodyear (2015) argues that crystallising good pedagogy into designed artefacts also transforms recurring investments of time, effort, and resources into durable educational assets. Moreover, he points out that design inherently involves resolving tensions between competing objectives, adding a layer of complexity often overlooked in traditional instructional design paradigms, which typically focus on optimising instruction for singular, straightforward goals. Understanding teaching as a form of design is therefore crucial for appreciating the intricate interplay that occurs when educators utilise learning materials.

2.2.1 Between Pedagogy and Design

This section integrates concepts from inclusive pedagogy and design thinking to deepen the theoretical foundation of design within this research. It aims to clarify what design entails in this context and to situate these ideas within the broader field of education.

Inclusive pedagogy

The term inclusive pedagogy is used here to describe a shift in teaching and learning from an approach that accommodates the needs of most learners, with additional provisions for those who experience difficulties, to one that fosters a rich learning community. This approach emphasises creating learning opportunities that are universally accessible, ensuring that all learners can actively participate in classroom activities (Florian & Black-Hawkins, 2011). Florian and Black-Hawkins argue that examining teachers' practical knowledge—often referred to as craft knowledge (Black-Hawkins et al., 2009)—can offer valuable perspectives on what educators need to know, as well as how they can be effectively prepared and supported to teach in schools that embrace inclusion for every learner.

Research has shown various strategies for preparing prospective teachers to work with students with disabilities. For example, Getzel and Thoma (2008) found that faculty members who were more knowledgeable about the characteristics and needs of students with disabilities were more likely to provide support to these students. Maher et al. (2020) employed vignette-based activities to help 90 prospective physical education teachers simulate visual impairment and design learning activities for peers role-playing as students with visual impairment. Similarly, Murray et al. (2008) reported that teachers' attitudes towards disability were positively influenced by their experiences and training in the field. Scott et al. (2003) argue that inclusivity is closely tied to the nature of interactions between teachers and students, suggesting that teachers should prioritise personal connections with their students. In line with this, Lipka et al. (2019) found that students with disabilities highly value their teachers' empathy, care, and commitment to accessibility.

Despite these insights, many teachers still rely on standardised lesson designs and express feeling unprepared to effectively address the diverse needs of all learners (Adefila et al., 2020; Griful-Freixenet et al., 2017). Research indicates that pedagogical strategies deemed effective for students with disabilities can also heighten teachers' awareness and motivate the adoption of more inclusive teaching practices (Florian & Linklater, 2010; Jordan et al., 2010; Robinson, 2017). In light of this, it becomes essential to provide teachers with clear, actionable guidance on how to design learning experiences that accommodate and engage all students.

Design as a mindset

The adoption of design thinking in education has been hindered by a lack of clear conceptual understanding (Panke, 2019). Wrigley and Straker (2017) point to a significant evolution in how design thinking is perceived—shifting from viewing it primarily as a set of cognitive strategies employed by professional designers, to recognising it as a mindset and method that non-designers can adopt and apply. This marks a move "*from design as a science to design as a mindset*" (Wrigley & Straker, 2017, p. 2). Johansson-Sköldberg et al. (2013) further clarify this distinction by dividing the discourse into two strands: *designerly thinking*, which originates from the practices of trained designers, and *design thinking*, which focuses on how design methods are interpreted and used in broader, often interdisciplinary, contexts:

> "One we call 'designerly thinking'. This refers to the academic construction of the professional designer's practice (practical skills and competence) and theoretical reflections around how to interpret and characterize this non-verbal competence of the designers. Designerly thinking links theory and practice from a design perspective, and is accordingly rooted in the academic field of design.
>
> The other discourse is 'design thinking'. We reserve this term for the discourse where design practice and competence are used beyond the design context (including art and architecture), for and with people without a scholarly background in design, particularly in management. 'Design thinking' then becomes a simplified version of 'designerly thinking' or a way of describing a designer's methods that is integrated into an academic or practical management discourse."
> (Johansson-Sköldberg et al., 2013, p. 123)

According to Panke (2019), the potential uses of design thinking in education are outlined in Table 2.1, highlighting opportunities for developing multidisciplinary design thinking initiatives within the educational sector. Expanding on this, Panke and Harth (2019) present design thinking as both a conceptual lens and a methodological tool that encourages dialogue and fosters inclusive, diverse learning environments. Retna (2016) also supports this perspective, noting that educators see design thinking as a powerful approach for cultivating key skills such as creativity, collaboration, problem-solving, communication, and empathy—skills that benefit students within and beyond the classroom context. Carroll et al. (2010) emphasise the necessity for teachers to recognise the value of design thinking in their classrooms. They argue that understanding the connection between design thinking and academic objectives is crucial for its effective implementation. This recognition ensures that design thinking is not perceived merely as an add-on but as an integral component of the educational process.

Table 2.1. The potential of design thinking for education and applied in different educational settings (based on Panke, 2019).

<table>
<tr><th>Potential</th><th colspan="2">Application</th></tr>
<tr><td rowspan="11">1) Tacit experiences
2) Increased empathy
3) Reduced cognitive bias
4) Playful learning
5) Creating flow/verve
6) Disciplinary collaboration
7) Productive failure/
Increasing resilience
8) Surprising solutions
9) Creative confidence</td><td rowspan="4">Informal learning settings</td><td>designing exhibits, experiences and services</td></tr>
<tr><td>service learning and organisational collaboration</td></tr>
<tr><td>extending exploration of artifacts, spaces and services</td></tr>
<tr><td>making and crafting</td></tr>
<tr><td rowspan="7">Formal education settings</td><td>as an instructional design method in course material development</td></tr>
<tr><td>as a curricular development technique</td></tr>
<tr><td>as a teaching strategy to achieve subject-specific learning goals</td></tr>
<tr><td>as a learning goal in and of itself</td></tr>
<tr><td>as a facilitation technique in student support</td></tr>
<tr><td>as a method for process improvement or product development</td></tr>
<tr><td>as an approach for leadership and organisational development</td></tr>
</table>

The motivations for incorporating design thinking into education are thus multifaceted. Educators are driven by the potential to generate innovative ideas, elegant solutions, and novel concepts. They aim to facilitate learning and development through engaging and dynamic formats while striving to cultivate transferable skills and competencies among students.

Synergies

> “The object in presenting these considerations is to defend the eminently pedagogical character of the revolution.” (Freire, 1970, p.49)

The integration of pedagogy and design ultimately leads to more inclusive, engaging, and effective educational practices. Gale et al. (2017) propose that pedagogy consists of three interrelated elements: belief, design, and action. They suggest that design functions as the *grammar* of pedagogy, shaping its structure through the sequencing and timing of pedagogical actions, the inclusion and exclusion of specific exercises, and the arrangement of the physical and social environments in which teaching occurs. As discussed in Section 1.2, Dillenbourg (2013) introduces the concept of *orchestration* to describe how teachers manage complex, multi-layered activities in real-time within a context of various constraints. Designing for orchestration requires facilitating the dual flow of information across both digital and physical spaces, recognising that, alongside learning objectives, teachers must navigate constraints such as time, discipline, curriculum, and energy. Some design principles—such as flexibility, visibility, minimalism, and physicality—appear to address these challenges.

Pedagogic design is often guided by specific beliefs about teaching and learning. For instance, a belief that all students contribute valuable knowledge to the learning environment calls for a design that incorporates and builds on these “funds of knowledge” (Moll et al., 1992). The ways in which students’ diverse knowledge are included are also critical. Students from marginalised groups, for example, not only bring different types of knowledge to the classroom but also bring distinct ways of knowing (Gale, 2012; Thomson, 2002). Pedagogical actions can, and should, be designed in various ways to accommodate these differences. Dewsbury and Brame (2019) argue that true inclusivity is a collective effort, urging teachers to utilise local and national networks to maximise both student learning and inclusion.

A relational account of thought and action further clarifies why design operates as pedagogy. A hermeneutic perspective views understanding as a circular movement between interpretation and enactment, where meanings are negotiated in dialogue and in contact with materials (Gadamer, 1979). In education, this becomes praxis—the unity of reflection and action oriented to transformation—so that reading a situation and redesigning it are inseparable (Freire, 1970). In design-intensive classrooms, teachers and students “think-in-action”: they frame, try, and reframe tasks through sketches, prototypes, and bodily routines, making their reasoning public and revisable (Schön, 1983). This also explains the need for orchestration under constraint: plans and scripts guide but cannot determine what happens; they function as resources for situated action (Suchman, 1987), which underscores the value of flexible and visible arrangements noted above. Put differently, co-design couples interpretation with material doing; learning occurs through iterative moves in which actions test and develop ideas (Dewey, 1963).

Inclusive pedagogy therefore extends to the belief, design and action of social and cultural responsiveness (Gay, 2018; Richards et al., 2007), practised by both teachers and students as a learning activity. Pedagogy that incorporates design thinking can be practised as a collective design activity, where both teachers and students contribute to the learning process. When this happens I call it a ***co-design pedagogy***, inferring that it is both social and reciprocal.

2.2.2 Teachers, Professional Identities, and Curriculum Resources

The influence of personal factors—such as beliefs, commitments, experience, and understanding of materials—on teachers’ pedagogical decisions is well established in the literature. Previous studies examining teachers’ use of learning materials have consistently demonstrated the importance of these factors in shaping decisions related to material selection and application (Lloyd, 1999; Manouchehri & Goodman, 2000).

The studies reviewed in this section further explore the complex interplay between teachers of students with visual impairments (TVI)'s competencies, knowledge, and their engagement with curriculum resources, emphasising how these elements collectively impact instructional practices.

TVI at work

The importance of ensuring that all VIC receive services from qualified teachers is well-documented (Spungin & Ferrell, 2000). Several key characteristics of the work of teachers who specialise in teaching VIC have been identified by Brown and Beamish (2012). One such characteristic is the complexity of the role (Benton, 1984). Teachers must continuously adjust learning environments, modify student plans, share information with other staff members and families, and regularly update their technical knowledge to meet the evolving needs of their students. Another defining feature is the uniqueness of the role (Silberman & Sacks, 1998). TVI work with a low-incidence population that has highly specialised educational and social needs. Additionally, the flexibility and diversity of expected practice is another important aspect of the work (Kim & Corn, 1998; Turnbull, 1995). Teachers must work with a varied group of students across different educational settings, requiring adaptable and diverse teaching strategies. Consequently, the daily work of TVI is often described as particularly challenging (Swenson, 1995).

GriffinShirley et al. (2004) found that teachers spent an average of eight hours per week on non-teaching duties, seven hours per week teaching functional academic skills, and two hours per week teaching O&M skills. Suvak (2004) surveyed 322 TVIs in Colorado to explore their everyday responsibilities. While the TVIs spent most of their time teaching Braille reading and writing, the most frequently performed tasks included ordering books and materials, teaching O&M, and producing large-print materials.

Teachers and curriculum resources

> "An important challenge for future research is to understand the component skills that visually impaired children must acquire to achieve graphicacy, and to develop teaching resources to promote these skills." (Sheppard & Aldrich, 2001, p.96)

The connection between teachers and curriculum materials is often described as that of an agent interacting with a tool (Herbel-Eisenmann et al., 2009). In the context of visual impairment, Erin (2014) asserts that the diversity of school environments, student needs, and experiences makes the concept of a standardised teaching model elusive. Given this variation, teachers often develop different approaches to achieving educational goals, influenced by local resources, settings, and the unique needs of their students. Research consistently shows that teachers respond to these challenges by creatively adapting existing resources to design personalised learning experiences (Erin, 2014). For instance, at the California Schools for the Blind and for the Deaf, Smith and Herlich (2014) highlight how professionals collaborated across institutions to support deaf-blind students by combining their specialized expertise. Likewise, Daugherty (2014) illustrates how the Texas School for the Blind and Visually Impaired responded to a more diverse student body by implementing a mix of statewide initiatives and short-term programs.

Early intervention professionals working with VIC can access professional development through a variety of resources, including books, research articles, conferences, peer and professional networks, eLearning opportunities, and online platforms (Ely & Ostrosky, 2017). However, Ely and Ostrosky (2017) highlight a potential barrier: the time required for professionals to locate and review these resources. Additionally, the cost of certain materials may limit access, meaning that some teachers may be unaware of, or lack access to, essential resources.

To gain deeper insight into how teachers engage with curriculum resources, it is important to consider the factors influencing teachers' decision-making processes.

The central role of visual representations in STEAM education may place students with visual impairments at a disadvantage, potentially affecting their proficiency in these fields and limiting their future access to this growing workforce sector (Bell & Silverman, 2018; Rau, 2017). Mwakyeja (2013) emphasises the importance of teaching materials for VIC, noting that TVIs are increasingly focused on adapting resources, particularly in the use of models. Zebehazy and Wilton (2014) point out that a key challenge lies in the limited direct instruction students receive on how to interpret and utilise graphics. While the Guidelines and Standards for Tactile Graphics (BANA, 2010) offer technical recommendations for designing tactile graphics (TG) for Braille users, they fall short of providing practical guidance for TVIs on how to introduce and teach the structured use of these graphics. Additionally, as Rosenblum et al. (2018) observe, there is currently a lack of standards for adapting graphics for visually impaired students who rely on print rather than Braille.

Knowledge, skills, and competencies

The responsibilities of Teachers of the Visually Impaired (TVIs) are shaped by multiple dynamic factors. First, evolving student demographics, the nature of services required, caseload size, and the degree of administrative support and awareness regarding the unique needs of VIC significantly impact TVI roles (Griffin-Shirley et al., 2004). These elements, coupled with growing global emphasis on inclusive education, have led to notable shifts in how TVIs operate. Second, TVIs must work closely with various school staff and families to ensure that VIC have equitable access to the curriculum, can meaningfully engage with learning materials, and achieve positive educational outcomes (Brown & Beamish, 2012). Third, the current emphasis on data-informed practices has increased TVIs' administrative responsibilities, requiring more time to be devoted to documentation, planning, and assessment processes (Bishop, 2004; Spungin & Ferrell, 2000). Fourth, the presence of additional disabilities among VIC further complicates the roles of TVIs. Fagliano (1998) reported that up to 50% of VIC have one or more additional disabilities. In light of this, Silberman and Sacks (2000) advocated for TVIs to broaden their expertise to include areas such as assessments, leisure and recreation, sexuality education, motor and cognitive development, social skills, and vocational training.

Although research into the professional scope of TVIs has been relatively limited over the past two decades, several pivotal studies have attempted to clarify their roles. For example, Spungin and Ferrell (2000) expanded on their earlier work (Spungin & Taylor, 1986) by compiling a detailed account of TVI responsibilities in the US. Dote-Kwan et al. (2001) conducted a survey involving 121 early childhood educators in California, identifying 12 core professional duties—such as visual skills training—that were widely regarded as essential for supporting young children with visual impairments. Similarly, Wolffe et al. (2002) examined TVI practices across six states to assess their effectiveness in preparing students for adulthood. Their findings revealed that while academic instruction was prioritised, there was comparatively less emphasis on teaching specialised disability-related skills, promoting communication abilities, or fostering collaboration with mainstream educators.

2.2.3 Factors Influencing Design Decisions

Recent scholarship has begun to integrate the expanding body of research on how educators construct instructional environments and the kinds of support they require to excel in this design role (Asensio-Pérez et al., 2017). When teachers' engagement with curriculum materials is viewed through the lens of design activity, it becomes evident that some educators may possess more advanced capabilities in crafting effective learning contexts than others.

The field of learning design is theoretically grounded in a sociocultural perspective (Conole & Dalziel, 2016), which views design as context-dependent and influenced by the specific circumstances of the teacher. This approach also frames design as an artefact-mediated process, whereby tools and resources help structure and articulate teachers' design thinking, facilitating the sharing and reuse of designs within communities of practice (Mor et al., 2013). Understanding pedagogical design capacity, therefore, has important implications for teacher preparation, the design of instructional materials, and the evaluation of instructional practices by researchers and school officials. For TVIs, this notion of design work is further complicated by the need for a nuanced and specialised knowledge base that is not always addressed in general education discourse.

This section reviews key studies that explore these issues in depth (Rong et al., 2025). Table 2.2 presents a selection of empirical research focused on factors influencing instructional design decisions in the education of visually impaired learners. Analysis of these studies reveals several recurring themes: 1) educator-related factors, 2) user-related factors, 3) technical factors, 4) contextual factors, and 5) pedagogical factors. These categories are examined further in the discussion that follows, supplemented with insights from additional relevant literature.

Table 2.2. Summary of empirical research on factors affecting design decisions in in VIC learning.

Study	Factors identified	Context	Methodology & Participants
Sheppard & Aldrich (2001)	Teacher's factor Pedagogical factor User's need	UK	・Questionnaire ・24 TVIs
Lawrence & Lobben (2011)	Technical factor User's need	US	・Experiments ・12 participants
Rule et al. (2011)	Teacher's factor Pedagogical factor Students' factor	US	・Questionnaire, 15 teachers each wrote a narrative ・13 VIC and 15 teachers
Engel & Weber (2017)	Technical factor User's need Institutional factor Teacher's factor	Germany	・Survey ・ 71 participants (34 blind, 7 visually impaired, 30 sighted)
Rosenblum et al. (2018)	Student's factor Pedagogical factor	US	・Focus groups ・11 TVIs
Gupta et al. (2019)	Technical factor Student's need	India	・Experiments ・1)14 students of National

			Association for the Blind (NAB)New Delhi ・2) 21 participants (students, teachers and staff of NAB New Delhi) ・3) 10 students of NAB New Delhi
Lee (2019a)	Contextual factors	Taiwan	・Questionnaire, experiments ・60 visually impaired associations ・Experiment 1: 79 students ・Experiment 2: 77 students
Mukhiddinov & Kim, 2021	Technical factor Educator's factor	Korea	・Systematic literature review
Phutane et al. (2022)	Teacher's factor Student's factor Technical factor	US	・Interviews ・21 TVIs

Educator-related factors

TVIs often design their own TG, despite having access to ready-made materials from textbooks and centralised resources (Sheppard & Aldrich, 2001). Unlike specialised producers of TG, TVIs can continuously assess the effectiveness of these resources within the specific context of their classrooms. This allows them to tailor the graphics to the needs of VIC whose abilities they are familiar with. However, Sheppard and Aldrich (2001) note that teachers face significant challenges in helping VIC understand all but the simplest TG, and that additional supplementary materials and support are often required. Whenever possible, teachers prefer to use real-life objects rather than relying on diagrams or models, particularly where a tactile graphic only conveys a brief concept or presents a single question. One key hindrance is the time-consuming nature of creating TG, which limits their frequency of use in classroom settings.

Rule et al. (2011) support the idea that with knowledgeable, supportive teachers and appropriate accommodations—such as tactile or auditory materials—students with visual impairments can succeed and engage in science and mathematics at the same level as their sighted peers. They also emphasise the importance of teachers' attitudes in fostering inclusive learning environments. Their study found that participation in projects designed for VIC increased teachers' awareness of the need for specialised materials to ensure equitable learning opportunities. This led to a shift in attitudes, including recognition of the need for additional funding to purchase adaptive materials.

Engel and Weber (2017) examined the creation and use of tactile charts in educational settings, noting that non-experts, such as teachers, often take on the responsibility of producing these curriculum resources. A common practice is to transcribe visual charts from teaching materials to make them accessible to blind students, thus enabling them to learn visual concepts. However, the time and hardware limitations faced by teachers complicate this process. Many institutions only have one embosser for printing TG, meaning that teachers often must prepare materials alongside their regular teaching duties. Rosenblum et al. (2018) found that TVIs frequently adjusted the visual attributes of graphics—such as increasing contrast, adding colour, and using highlighting—to enhance accessibility for their students. Prescher et al., (2014) also note that the development of tactile charts is a labour-intensive task that requires specialised knowledge of tactile design.

The introduction of interactive audio-tactile methods, such as the TPad system, has shown promise in accelerating the learning process for VIC (Melfi et al., 2020). However, while the system holds potential, it can increase teachers' workloads, as few educators are trained to create TG using a Braille embosser (Mukhiddinov & Kim, 2021). Moreover, the use of augmented reality (AR) to create audio-tactile graphics from real objects presents an innovative direction in the field (Thevin et al., 2018). This method allows teachers to design pedagogical content from real objects, making it more relevant and engaging for students. However, the implementation of AR systems in classrooms requires time for teachers to become proficient and additional funding from schools to support its integration into everyday teaching practices.

User-related factors

Gupta et al. (2019) emphasise that understanding VIC's needs is fundamental to effective design. Sheppard and Aldrich (2001) also note challenges in adapting TG from visual graphics without sufficient consideration of the specific needs of blind users. Previous research has highlighted that VIC often struggle to develop the skills necessary to access graphical information efficiently and accurately (Rosenblum et al., 2018). For instance, a survey of TVIs revealed that only about 20% of teachers felt their students could independently use math graphics.

Regarding individual differences, Lee (2019a) observed that factors such as gender, grade level, visual status, and the condition of blindness did not significantly affect identification performance. Nonetheless, the study revealed notable disparities among groups concerning IQ levels, memory capabilities, and proficiency in Braille. In line with these findings, Barth (1982) also reported no significant impact of grade level when assessing the interpretation of tactile symbols. Similarly, Ng and Chan (2014) concluded that gender did not play a significant role in the tactile discrimination of geometric figures.

Rosenblum et al. (2018) further suggest that VIC possess varying sensory strengths, and part of the role of TVIs is to identify the most effective way for each student to gather information. Based on this assessment, TVIs can tailor the design of TG to suit individual sensory preferences, ensuring more effective learning experiences.

Technical factors

Various production methods for representing tactile symbols, such as thermoforming, swell paper, embroidery, and 3D printing, can influence the readability of these symbols (Gual et al., 2015; McCallum et al., 2005; Ramsamy-Iranah et al., 2016). The creation of TG can be particularly challenging when complex images, such as protein structures, need to be converted into tactile representations. This process can be difficult for teachers and researchers to manage (Mukhiddinov & Kim, 2021). Although Braille text conversion is often precise, issues persist in creating TG from complexly shaped images. For example, Race et al. (2019) used a microcapsule fuser and paper to create TG of schematics in school textbooks. However, this method was static and required different settings and human interaction for each electronic circuit. While experts can create TG manually, this approach remains time-consuming (Mukhiddinov & Kim, 2021).

Additionally, TG can sometimes overwhelm students with excessive tactile stimuli, leading to confusion. Students have reported difficulty with unclear diagrams and inadequate Braille labeling (Aldrich & Sheppard, 2001; Rosenblum & Herzberg, 2015). To address these challenges, technologies have been developed to streamline the creation of tactile materials. For example, some systems automate the conversion of visual images into TG (Ladner et al., 2005), while others convert table-based coordinate spaces into tactile formats (Braier et al., 2015) or 3D print high-resolution models (Gual et al., 2014). Although these technological innovations have shown promise in laboratory studies, their integration into classroom practice remains a challenge (Phutane et al., 2022).

Contextual factors

Visually impaired individuals often rely on specialists to create alternative forms of spatial graphics (Ducasse et al., 2018). The act of constructing data visualisations has been shown to offer several benefits, including deeper understanding of datasets, critical engagement with the visualisation process, and the ability to reflect on data in the context of personal actions and values (Bishop et al., 2020; Rosenblum et al., 2018). However, in terms of visual symbols, Lee (2019a) notes that graphic symbols used in public environments and on visual maps are typically intended for sighted individuals to indicate the location of public facilities or directions. However, these symbols are generally not designed with the needs of the visually impaired in mind. In Taiwan, for example, there is no standardised system for tactile map symbols; the choice of symbols is usually determined by the manufacturer or the customer.

Research has also explored interactive systems that use commercially available refreshable displays to produce dynamic tactile maps with geographic commentary (O'Modhrain et al., 2015; Zeng et al., 2012). While these systems show promise, they are often prohibitively expensive. The cost of a refreshable tactile display ranges from 2,000 USD for an 18-character display to 50,000 USD for a half-page Braille display, making such technology unaffordable in many countries.

Pedagogical factors

TVIs emphasise the importance of tailoring instructional approaches to the individual learning styles and needs of VIC (Rosenblum et al., 2018). TVIs highlight the necessity of scaffolding instruction by initially modeling how to work through a graphic, followed by providing students with opportunities to solve problems independently. Furthermore, they stress the value of using the same language and terminology as general education teachers, particularly in subjects like mathematics, to ensure consistency and better integration with the broader curriculum. In a similar vein, Rule et al. (2011) found that TVIs frequently adapt their teaching, management, and assessment strategies to better meet the needs of students with visual impairments. These modifications reflect a commitment to creating an inclusive learning environment that supports the academic success of VIC.

Finally, one of the most frequently cited challenges impacting design decisions is the limited time teachers have to dedicate to thoughtful design and innovation, largely due to increasing workloads. This issue is particularly pronounced in the context of VIC education, where lesson planning demands additional time for the advance preparation and creation of tactile learning materials.

2.3 Materials, Materiality, and Materiality of Learning

In exploring the recursive relations between learning and learning activity, I have chosen to start with materials in use. This choice is motivated by both theoretical considerations, reflecting broader philosophical inquiries into the nature of being or becoming (Bergström et al., 2010; Ingold, 2011, 2012), and practical concerns regarding how learners engage with complex, open, and artifact-mediated learning activities. As such, it is a practical solution to the problems raised by what has only recently been acknowledged to be a silence on materials in the literature across disciplines and in design research more specifically.

This section explores the material qualities and properties, as well as the constructs of materiality. The progression, therefore, is from materials for learning, to abstract notions of materials for learning, culminating to a systemic notion of learning in which the properties of materials are both considered and accounted for in the processes of knowledge constructed.

2.3.1 Materials in Learning

Forms of technology

> "Considerable effort has been made to making sense of what we mean by "learning."...However, it is not the whole story. An account of educational technology that can only explain "education" and not "technology" runs the risk of dealing naively with an important part of its field of study. The consequence of this is a failure to provide convincing accounts of the link between technology use and learning." (Oliver, 2013, p.31)

Technology is often treated as a "natural" or given element in educational research, with little focus on its intrinsic role (Oliver, 2013). In many cases, its significance has been theorised and seen as secondary, contributing to broader understandings of learning or social impact rather than being important in its own right. For instance, some theoretical work on design-based research views technology as a tool for instantiating and developing theory (Barab & Squire, 2004), while other scholars conceptualise it as part of a system of distributed cognition or learning, rather than as a self-contained artefact (Kim & Reeves, 2007; Saljo, 2010).

The transformative potential of digital technology in education has been a central theme in research and development for decades. Discussions about the role of technology in education date back to the late 1950s and early 1960s, when the first developmental activities were initiated. By the early 1980s, personal computers, such as the Apple and IBM PC, began spreading to schools and universities (Saljo, 2010). Although these tools were initially used primarily for administrative purposes (e.g., scheduling, documentation), their potential for enhancing education became increasingly apparent, sparking debates about their role in schools. A lively discourse emerged between techno-utopians, skeptics, and those adopting a more neutral stance (Boichenko, 2021; Callen & Austin, 2016; Saljo, 2010). Visionaries predicted that the future would see the obsolescence of traditional schools, with computers taking over the central instructional role (Papert, 1980, 1986). Similarly, some researchers expressed skepticism about the revolutionary impact of digital technology on educational institutions (Bennett et al., 2008; Collins & Halverson, 2018). The initial vision of computers as instructors capable of guiding students through learning materials led to fears among teachers, that their roles could be supplanted by technology (Saljo, 2010). This debate continues, with educators questioning how best to adapt to and integrate these technological changes.

As different learners learn in different ways (Kaplan, 2002), the ideal technology aim to cater to these varied learning styles, offering multiple pathways for learners to engage with content. The proliferation of technology in education has expanded access to knowledge. The widespread availability of computers in classrooms, coupled with broadband internet, has opened up vast educational resources, making distance education and online learning more accessible. This growth has been particularly evident since the COVID-19 pandemic, with new learning management systems continually emerging (Adedoyin & Soykan, 2023; Fajri et al., 2021; Maatuk et al., 2022).

Regarding the research and development of technologies for children with disabilities (CwD), several key areas of inquiry have emerged. First, the potential for individualizing instruction through technology has been seen as particularly promising. The challenge of adapting teaching methods to meet the diverse needs of students with disabilities remains significant. Alper and Goggin (2017) highlight that although two-thirds of the world's nearly 3 billion internet users are from developing countries, only 5-15% of individuals who require assistive technologies for societal participation in these regions have basic access to such tools. The disparity in access to technology is a major barrier to the effective inclusion of CwD in educational settings. Second, technology has been applied to computer-assisted learning to create more engaging and tailored learning materials for CwD. Lin et al. (2012) note that advancements in technology can help design resources that cater to the specific needs of these learners. Adebisi et al. (2015) emphasise that the global adoption of computers, communication devices, and environmental control systems has provided CwD with essential tools for success in school, work, and independent living. Despite these advancements, some researchers point to persistent challenges in integrating Information and Communication Technology into established educational practices. Saljo (2010) observes that while the introduction of computers has the potential to improve academic performance, solid evidence for significant improvements is scarce. In other words, technology does not automatically enhance educational practices, and its effects may not be uniform across contexts. Nevertheless, in spite of this, it is evident that much of the contemporary discourse on how to organise learning, reform schooling, and prepare competent citizens now takes place within the framework established by recent technological developments.

Forms of knowledge

The exploration of knowledge can be understood as an exploration of the knowledge of things. Over the past few decades, there has been a growing body of scholarship focused on understanding knowledge as situated within practice. This shift represents a response to the longstanding tradition that views knowledge as primarily located within the mind (Taylor, 1985). The debate between rationalism and empiricism has been central to the history of philosophy. Rooted in Plato's dialogues, rationalism has traditionally conceived knowledge as something elicited from the mind, whereby attention is drawn to what the mind already processes. Conversely, in Locke's empiricism, the mind is viewed as a *tabula rasa* (blank slate) at birth, with knowledge inscribed through sensory experiences and observations of the world (Soles, 1985). Kant, however, critiqued both traditions, offering a synthesis of their insights. For Kant, the empiricist gains the content of knowledge through experience, while the rationalist deduces its form. Yet, both approaches suffer from limitations: empiricist knowledge lacks form, while rationalist knowledge lacks content (Kant & Walford, 1992). Both traditions still view knowledge as located in the mind, though for empiricists, its source is external, in the world itself (McCormick & Paechter, 1999).

In contrast to these mentalist conceptions, situated knowledge theories argue that knowledge is not intrinsic or purely mental but is constructed through action. Knowledge, from this perspective, is not individual but situated in the "lived-in world" and shared within communities of practice. Lave (1988), for instance, explored how mathematical cognition is situated within the everyday practices of shopping in supermarkets. In a similar vein, Sørensen (2009) explored how children transfer knowledge acquired through health education computer games to real-world contexts, such as navigating supermarket environments. Building on related ideas, Lave and Wenger (1991) conceptualised learning as situated within communities of practice. They argued that knowledge is not isolated but exists within "a set of relations among persons, activity, and the world, over time and in relation to other tangential and overlapping communities of practice" (Lave & Wenger, 1991, p. 98).

While situated learning theory emphasises the active role of learners in constructing understanding through their interactions with artifacts, it does not fully address the ontological aspects of the sources from which learners derive their conceptions of knowledge (Greeno et al., 1996; Lave & Wenger, 1991; Wells, 1999). The early constructivist assumption that direct personal experience forms the basis of knowledge construction is increasingly being challenged. Scholars now argue for the importance of social interaction in shaping individuals' knowledge-building processes, suggesting that people actively influence each other's understanding (Hatano & Wertsch, 2001; Tomasello et al., 2005). Cognitive growth models, which emphasise discrete developmental stages, often rely on implicit notions of *innate* or biological mechanisms to explain a learner's readiness to progress from one stage to the next (Cole, 2013; Rogoff, 1990). While I accept the general framework of knowledge as part of "a set of relations among persons, activity, and the world," I prefer to describe knowledge as a collective, tool-mediated activity situated within a cultural and historical context (Engeström, 2001).

Forms of design

At the turning point in design, Ezio Manzini (1989) articulated a shift from *being* to *doing* materials. This transition highlights the dynamic role materials play in shaping both the design process and its outcomes. Building on Manzini's work, Bergström et al. (2010) argue that design decisions influencing the potential of materials are made early in the material development process, with significant implications for both design practices and the subsequent use of the materials. These materials, with their active and reactive capacities, continue to evolve within the specific, situated, and social contexts in which they are used. Anticipating this evolution must, therefore, be a fundamental part of the design and development process. This perspective calls for an expansion of the concerns and methods typically employed in material development, broadening the scope beyond conventional approaches.

Grigg (2020) highlights a key component of design ideation: the intentional engagement with the intrinsic properties of materials as a means of shaping and expressing ideas. While this approach is well-established in related fields such as architecture, it remains relatively underexplored in graphic design. However, the process of designing is often not well understood by non-designers (Grigg, 2020)—designers making intuitive and strategic choices about materials based on their capacity to support and influence visual communication. As Knight and Stiny (2015) note, viewing design as a form of "computing of things" challenges the conventional separation between designing and making. This idea underscores the complex, transformative role of graphic designers—likened by Barnard (2005, p. 16) to magicians who can "transform one thing into another... and make things appear." However, materials should not be regarded as passive carriers of meaning; their significance lies in what they can do. As Manzini (1989) argues, designers must move beyond asking "What is it?" and instead consider "What does it do?" to unlock the full potential of materials in practice.

The terms of *being* and *doing* provide a framework for understanding the behaviour of materials, which can transform in response to sensed events. But, they fail to capture the full scope of the expressions and experiences that arise from interactions with materials—elements that are crucial to understanding the design possibilities and challenges these materials present. This insight calls for a re-examination of how materials are related to in the design process, as Bergström et al. (2010) propose, urging a deeper engagement with the continuous transformation of materials in design practice.

2.3.2 Materiality in Learning

> "To understand materiality, it seems, we need to get as far away from materials as possible." (Ingold, 2007, p.2)

Sørensen (2009) conceptualised materiality as the capacity to form connections with other entities, while defining learning as the development or expansion of knowledge. From this perspective, the materiality of learning can be understood as "the achieved ability of a growth in knowledge to connect to other particular entities" (Sørensen, 2009, p. 177), highlighting the interplay between knowledge development and its relational context.

Components

Pedagogy is rarely considered as a question of the deliberate or mundane orchestration of its materials, or as the coordination of various forces, sensations, narratives, invitations, habits, media, time, space, ideas, language, objects, images, and sounds. These elements are intentionally employed to engage the materiality of minds and brains, establishing connections with other material elements in the world (Ellsworth, 2005). According to Tilley (2006), materiality is a concept that pertains to the physical substance or components of things, emphasising the tangible or real aspects, as opposed to the imaginary or value-laden. From this viewpoint, objects or possessions have material significance for humans, who are the subjects interacting with them. Consequently, materiality is closely linked to the concept of common sense, which is grounded in objective evidence, in contrast to subjective ideas or values.

Embodiment

Isling Poromaa (2017) argues that materiality holds a formative power grounded in what Bourdieu (1990) calls the "pre-world"—a domain shaped by already established ends. This realm encompasses the design and quality of physical spaces and objects, which in turn structure the conditions for their use. The pre-world is made up of objectively existing arrangements, serving external purposes and reflecting the habitus. Through these arrangements, social relations generate implicit rules or “procedures to follow” within a social space (Bourdieu, 1990). Within institutional contexts, shared values embedded in the material landscape can regulate, support, or constrain individual actions and beliefs (Bourdieu, 1977).

More recent perspectives move beyond earlier views of materiality, framing it as a fundamental structuring element (Bourdieu, 1977) that not only shapes practices but also produces values that inform how individuals interpret institutions like schools. For instance, tactile materials, which are regularly used by TVIs to convey concepts, enrich educational experiences for VIC. These materials can be seen as a product—the outcome of a material condition that forms the school’s habitus. When material conditions are tied to valued resources and associated with the social groups that occupy schools, the institution itself can be understood as a “sociomaterial” object (Fenwick et al., 2012).

Therefore, the concept of materiality is frequently employed in material culture studies to highlight the everyday practical benefits of objects, as opposed to their role in conveying value-laden meanings for humans; political theorists have used the term to describe the physicality of assemblages (Bennett, 2010), while educational researchers have applied it to explore *how materials relate to other entities* (Sørensen, 2009, 2011).

2.3.3 Properties of Materials

> “The properties of materials, then, are not fixed attributes of matter but are processual and relational. To describe these properties means telling their stories.” (Ingold, 2007, p.1)

If, as Ingold (2007) has suggested, we are to redirect our attention from the materiality of objects to the properties of materials, then raises the question: *what are these* *properties, and how should we describe them?* David Pye (1968) proposes that every material possesses inherent properties that can be either expressed or suppressed depending on its use. According to Pye, the properties of materials are not strictly objective nor merely subjective; rather, they are practically experienced. In this context, each material property can be understood as a "condensed story," encapsulating both the material's potential and the experiences it facilitates in use.

Sensory properties

As Merleau-Ponty (2004) observes, classical psychology often presents an object as a system of properties that are perceived through our various senses, with these properties being unified by an intellectual act of synthesis. For instance, the experience of a lemon might be described as "a bulging oval shape with two ends, plus the yellow colour, the fresh feel, and the acidic taste..." (Merleau-Ponty, 2004, p.59). However, modern psychology, following Goethe's insights, has shown that these sensory qualities are not entirely separate; rather, each quality carries an affective meaning that links it to corresponding qualities in other sensory modalities. For example, the qualities of sounds and tactile data are similarly interconnected, such that one might say a particular colour corresponds to a specific sound or temperature.

This interconnectedness explains why some PVI can envision a colour when it is described, drawing on analogies with, for instance, sounds. Merleau-Ponty suggests that by re-establishing a quality within its experiential context—a context that gives it emotional significance—we can better understand how it relates to other qualities that might seem unrelated at first. This is the case with the quality of being honeyed—symbolise a broader pattern of human behaviour, but it can only be fully understood through the interaction between the embodied subject (the person) and the external object that embodies this quality. This process illustrates that the definition of such a quality is inherently human, rooted in the subjective experience of perception. Viewed from this perspective, every sensory quality is interrelated with qualities from other senses. This interrelationship reflects the holistic nature of sensory experience, where the boundaries between distinct sensory modalities blur, creating a more integrated and embodied understanding of the world.

Cognitive properties

Drawing on Heidegger's concept of *being-in-the-world*, his primary concern was the ontological question of what it means to be. Heidegger argued that this fundamental question had been largely overlooked since the time of Plato. He found himself in direct opposition to Descartes' conception of the human being as a res cogitans—a thinking thing (Zahorik & Jenison, 1998). On this view, nothing is more immediate and self-evident than our own mental contents; the very act of thinking guarantees our existence. Heidegger, however, contending that the act of thinking is not sufficient to explain being. His approach to examining existence was grounded in hermeneutics, a method of interpretation that asserts meaning is contingent on context. Interpretation, Heidegger argued, is never purely detached or analytic, but is always shaped by the interpreter's beliefs, language, and social practices. In this regard, Heidegger believed it was impossible to adopt a detached, purely analytic viewpoint when examining what it means to be, as such an examination is always embedded in specific physical, social, and historical circumstances.

This concept aligns with the theory of distributed cognition, as outlined by Hutchins (1991, 1995), which suggests that cognitive processes extend beyond the individual mind and are distributed across people, tools, and environments. The physical attributes of representational artifacts play a key role in determining how information is made available and accessible across time and space, affecting the flow of information within cognitive systems (Hutchins, 2000). Hutchins (1995) argues that "any attempt to explain the cognitive properties of the integral parts without reference to the properties of the larger system would be incomplete" (pp. 287-288). Distributed cognition, therefore, focuses on cognitive systems that include both individuals and their environments, emphasising the functional relationships between the components that contribute to cognitive processes (Hollan et al., 1999). From this viewpoint, learning is seen as "the adaptation of structure in one part of a complex system to organisation in the other parts. Some parts are re-organised inside the skin. The question of individual learning now becomes a question of how that which is inside a person might change over time as a consequence of repeated interventions with these elements of cultural structure" (Hutchins, 1995, p. 290). For PVI, materials function as cognitive tools that extend the mind, aiding in the structuring and organisation of knowledge. In this framework, the cognitive properties of materials are not passive or neutral; rather, they actively mediate and shape the cognitive processes of the learner. A tactile diagram, for instance, is more than just a representation of information; it is a tool that shapes the understanding of spatial relationships, concepts, and ideas through tactile engagement.

Overall, incorporating the cultural and historical context of materials (Engeström, 2001; Ingold, 2011) and observing how their material qualities change or persist over time (Shove et al., 2012), can provides valuable insights into the processes of change in learning and teaching practice (Sørensen, 2009).

2.4 Design for/with PVI

Design cannot be defined by a single, unified concept that encompasses all the varied ideas and approaches within the field. One of the foundational contributions to the field was made by Simon (1969), who examined the technical and empirical aspects of design, presenting it as a scientific process. Simon defined design as a methodical approach to problem-solving and decision-making, focused on changing current situations into more desirable ones (Simon, 1969). He highlighted the wide-ranging applicability of design across different contexts and professions, stressing the importance of employing systematic, investigative methods in the design process. However, Simon's positivistic epistemological approach has been criticised for promoting a technocratic view of design, which may not accurately represent the realities of designers' work (Dorst, 2004). Furthermore, his focus on prescriptive practice overlooked the social and collaborative aspects of design.

Building on pragmatist and constructivist traditions, Schön (1983, 1987) advanced an alternate epistemology of design practice. Drawing from John Dewey's inquiry theory, he framed "reflective practice" as a cycle of reflexive, creative, and experimental thought that produces new ideas, knowledge, and artefacts. Although Schön's perspective contrasts with Simon's more technical, rational problem-solving view, the two together offer a fuller understanding of design. Cross (2001, 2006) later broadened their epistemological foundations by coining "designerly ways of knowing," a term capturing the distinctive cognitive skills, processes, and mindsets that characterise designers (see Section 2.2.1). Cross (2001) writes,

> "Just as the other intellectual cultures in the sciences and the arts concentrate on the underlying forms of knowledge peculiar to the scientist or the artist, so we must concentrate on the "designerly" ways of knowing, thinking, and acting." (p. 55)

Buchanan (1992) highlights an important point often overlooked in design discourse: what many perceive as "impossible" may simply reflect a limitation of imagination, which can be overcome through better design thinking. In line with Cross (2001) and Buchanan (1992), this research views design as a dynamic and iterative activity that encompasses not only the creation of *solutions* but also the ongoing *process* of developing, testing, and refining those solutions (Figure 2.1). As Buchanan (1992) notes, "designer's task is to identify those conditions precisely and then calculate a solution (p.15)."

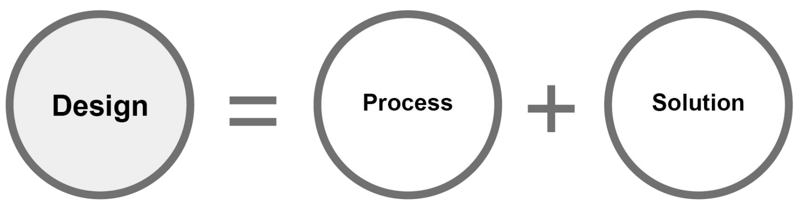

Figure 2.1. Design is both process and solution.

2.4.1 Design for-

TG are essential for PVI, supporting both learning and everyday activities (Rong et al., 2025). Although many countries are devising TG solutions, establishing universally applicable design guidelines remains challenging. By translating visual content—such as pictures, maps, charts, and other graphics—into tactile form, TG enable information to be perceived through touch. Existing standards from bodies like BANA (2010) and Braille Literacy Canada have brought welcome uniformity, yet further refinement is still required (Gorlewicz et al., 2020). Foundational research on tactile perception (e.g., Johnson & Hsiao, 1992) shows that successful TG must respect the tactile system's spatial limits and typical exploratory movements. Haptic-perception theorists likewise stress the value of active touch, recommending features such as varied textures and raised contours (Hughes & Jansson, 1994; Jacobson, 1998; Schneider et al., 2017). Consequently, TG design draws on insights from psychology, computer science, education, and graphic design.

According to the results of my previous scoping review on TG design for PVI (Rong et al., 2025), it reveals that most TG research is concentrated in Europe and North America—a pattern tracing back to the roots of inclusive and accessible design in the UK and US (Williamson, 2019). Work in Asia and South America remains sparse, revealing a significant opportunity for future development in these regions.

The co-occurrence map in Figure 2.2 positions "tactile map" as the most prominent node, marking it as a focal point in TG research for people with visual impairments. At the opposite side of the diagram sits the cluster around "tactile chart," linked with "chart," "data," and "example," signalling a strand of inquiry into representing quantitative information in tactile formats—essentially a sub-field on tactile data visualisation. Another grouping—"access," "touch," and "challenge"—centres on accessibility: how users physically explore TG ("touch") and the barriers they encounter (“challenge”). A final cluster that ties together “experiment,” “guideline,” “individual,” “school,” “teacher,” “system,” and “colour” points to practical and pedagogical concerns, especially the use and instruction of TG within educational contexts such as schools.

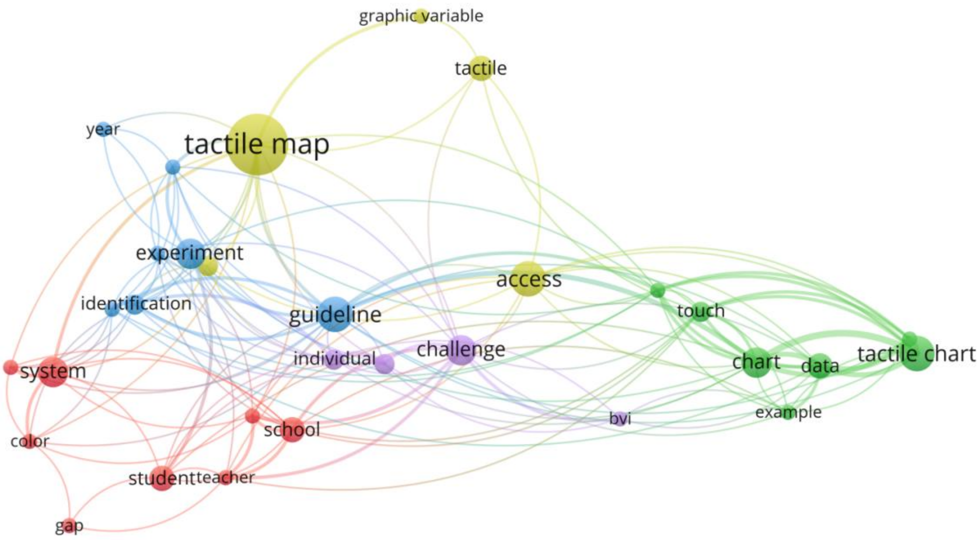

Figure 2.2. Co-occurrence map of emerging themes (Rong et al., 2025).

Rong et al. (2025) describe TG development as an end-to-end workflow that begins with gathering information and culminates in producing the finished tactile artefact. Figure 2.3 presents this workflow as a flowchart, showing how raw information is progressively converted into TG. The study underscores the value of actively involving PVI throughout the design process. Across the literature, TG effectiveness has been evaluated through user impressions (Engel & Weber, 2019; Panotopoulou et al., 2020), accuracy in interpreting the conveyed information (Fan et al., 2020; Lee, 2019a), and the ease with which users learn and understand the material (Aldrich & Sheppard, 2001; Vinter et al., 2020).

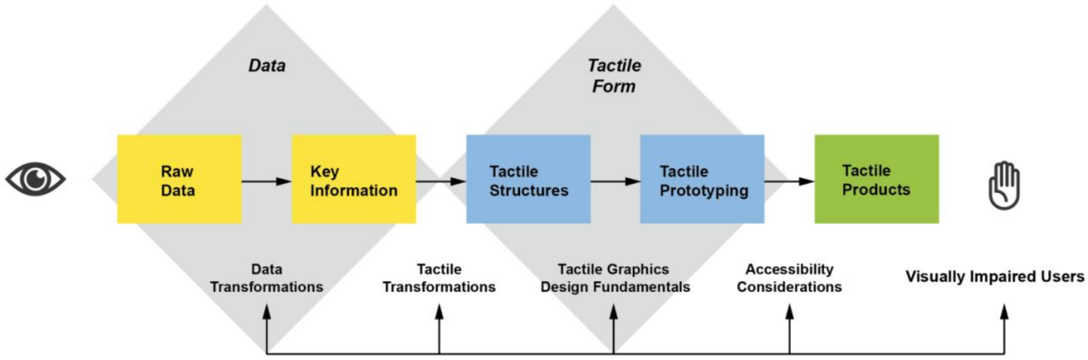

Figure 2.3. The pipeline of transforming information into tactile graphics (Rong et al., 2025).

Therefore, based on the research (Rong et al., 2025), design for PVI (Figure 2.4) is both a process of transforming, prototyping and testing and a product, as it leads to the creation of tactile products (learning materials in this study's context) to be used by PVI (specifically *for* VIC in this study).

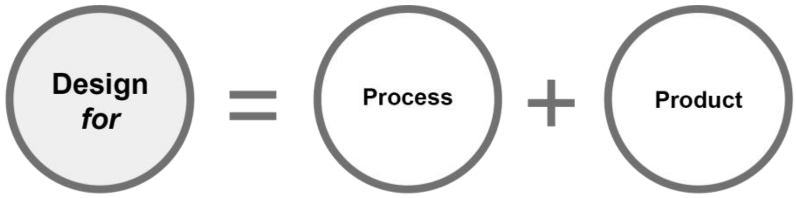

Figure 2.4. Design for PVI is both process and product.

2.4.2 Design with-

As previously discussed in Section 2.4.1, designing for PVI also emphasises the importance of involving PVI in the design process. participatory design in the studies reviewed emphasises values such as democracy, equality, representativeness, openness, and communication—considers participants not just as subjects of the study but as active contributors to the design outcomes. Yet even in participatory design's democratic framework, participation barriers remain—particularly for groups labelled 'vulnerable,' who are sometimes presumed unable to engage fully in collaborative work (Hodson et al., 2023). Design efforts with PVI focus on expanding and enhancing existing methods of participation, aiming to involve a broader range of people and ensuring accessibility for wider target groups, rather than creating "special" methods for "special" users with "special" needs (Magnusson et al., 2017).

Established co-design and participatory design techniques are, in fact, compatible with PVI; the chief challenge is that many conventional tools—Post-it notes, sketches, cards, videos, or low-fidelity paper prototypes—are visually oriented (Magnusson et al., 2017). Practitioners therefore adapt or reinvent these tools for non-visual engagement—for example, substituting pen-and-paper sketches with tactile prototyping materials, or attaching NFC/RFID tags to objects so they can be sonified—often through relatively simple adjustments. However, some adaptations, though seemingly simple, may require more effort than initially anticipated. For instance, lists of words related to emotions—such as happy, sad, or boring—often include terms like light, bright, or dark, which refer to visual experiences. An effective adaptation would need to ensure that words referring to sound and touch experiences are also included. Gupta et al. (2021) highlight the importance of using appropriate tools that participants are already familiar with or tools analogous to those they use in everyday life when designing with VIC. Their study focused on a specific centre and a small group of VIC from the local community in Guwahati, India; which Gupta et al. (2021) also note that exploring how cultural differences might influence design practices in this context presents an interesting avenue for further research.

In section 1.2 and 2.2.2, I have explained *orchestration* requires facilitating the dual flow of information across both physical and perceptual understanding which can serve as a useful metaphor for designers/teachers working with PVI, as it conveys two essential aspects. The pedagogical aspect emphasises the empowerment of teachers as facilitators of classroom activities. This does not equate to more lecturing; even constructivist approaches require skilled leadership (Dillenbourg, 2013). The design aspect, however, highlights maximalism, which necessitates additional effort to adapt or create activities that are suitable for non-visual use. Based on this definition, design with PVI (Figure 2.5) is both a orchestration of designing, mediating and managing and a product, as it leads to the creation of artifacts (learning materials in this study's context) to be designed with PVI (specifically *with* VIC in this study).

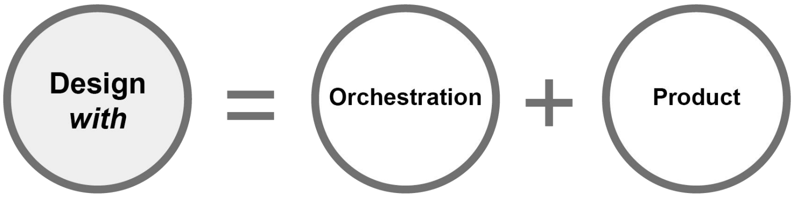

Figure 2.5. Design with PVI is both orchestration and product.

2.4.3 Challenges

Designing both for and with people who have visual impairment is rewarding yet demanding. A review by Rong et al. (2025) highlights how such work has propelled human-computer interaction forward, spawning tools like thermal printers (Iranzo Bartolomé et al., 2020), 3D printing solutions (Barvir et al., 2021; Nicot et al., 2021), and refreshable tactile displays (Gill & Pawluk, 2022). Even so, converting textual or visual information into clear tactile graphics remains difficult. Three challenges persist:

1) High-quality TG usually require specialist expertise and substantial production time, as fully automated pipelines are still lacking.
2) Although research in this area is relatively advanced, the complexity of current processes limits broad adoption and everyday use.
3) Most TG production workflows continue to depend on traditional, labour-intensive techniques, making them time-consuming to execute.

Design with PVI presents unique challenges that stem from the intersection of sensory limitations and accessibility barriers. One significant challenge is the adaptation of traditional design tools and methods, which are often heavily visual in nature, to meet the sensory and cognitive needs of PVI. Standard materials require substantial modification to become accessible to those with visual impairment. These adaptations can be resource-intensive, requiring time, expertise, and iterative testing to ensure that the final design is not only functional but also meaningful to the users involved. Moreover, the process of facilitating effective communication and collaboration between designers and PVI can be complicated by the varying degrees of accessibility in the design process itself, including the availability of assistive technologies or tactile resources. Additionally, the social dynamics of design with PVI often present difficulties, as PVI may face challenges in asserting their agency within participatory processes, especially when traditional design practices may not fully acknowledge or incorporate their lived experiences. In Magnusson et al. (2018), it is asserted that experience is the key to success, with the overall mindset of the team being identified as the primary factor; the design team's adoption of a co-creative mindset is conducive to the effective integration of tools, methods and activities. Accordingly, the next section examines co-design as enacted in educational settings, detailing the practices, tools, and collaborative protocols that translate these constraints into actionable opportunities.

2.5 Co-design in education context

> "One might even argue that design is always co-design because it is inherently a social process. Co-design comprises diverse approaches, ranging from research-oriented ones (e.g., applied ethnography) to design-oriented ones (e.g., using generative tools), and with a focus on user involvement, ranging from approaches in which researchers and designers move toward users (e.g., usability testing) to approaches in which users move toward researchers and designers (e.g., participatory design). Co-design often builds on the tradition of (Scandinavian) participatory design." (Steen, 2013)

The term co-design is frequently used interchangeably with participatory design, cooperative design, or collaborative design (Liegl et al., 2016). In education, it serves to develop curricula, learning environments, and technologies that address the needs of diverse learners, including students with disabilities (Rong &

Hansopaheluwakan-Edward, 2025). Engaging children in co-design can be highly rewarding—empowering them, generating unexpected ideas, and revealing their unique perspectives—yet it also poses difficulties. Children, especially those with disabilities, differ fundamentally from adults and often lack the design thinking and teamwork skills needed for active participation (Van Mechelen et al., 2019). Compounding this, design researchers are seldom trained as educators and may find it challenging to facilitate co-design sessions in school settings that involve CwD. The next section therefore revisits co-design in educational contexts, identifies its primary actors and their roles, and outlines the distinctive characteristics of co-design practice with CwD.

2.5.1 Co-Design as a Process of Learning

Co-design is widely recognised for its ability to facilitate knowledge transfer between participants and designers through hands-on design activities that position participants as experts in their own lived experiences (Lowy et al., 2024). A key outcome often emphasized in co-design with children is the concept of "*mutual learning*" (Bowler et al., 2021; Halskov & Hansen, 2015). Large et al. (2006, 2007) suggest that co-design reflects Vygotsky's concept of a socially supportive learning climate, in which individual expertise is gradually transformed into shared community knowledge. When adults and children pool their skills toward a common aim, the children's agency is not diminished; instead, everyone gains from the collective growth experience. Over time, such collaboration can foster children who are almost "expert" users, capable of generating ideas and posing increasingly sophisticated questions (Clarkson et al., 2013). Nevertheless, reciprocal learning is not guaranteed. For innovation to emerge, participants and designers must be open to seeing things in new ways, as mutual learning thrives in environments where both parties can share and expand their perspectives (Fischer et al., 2020; Robertson & Simonsen, 2013)

Drain and Sander (2019) propose a collaboration system model (Figure 2.6) to explain the mechanisms of knowledge transfer in participatory design. This model emphasises that both the designer and the participant contribute valuable knowledge and experience to the collaboration through different mechanisms. It situates the collaboration within the broader socio-cultural context, while also recognising the controlled design environment in which the project unfolds. Although mutual learning is widely acknowledged as a key benefit of open, trust-based collaboration, co-design research has seldom probed the specific ways these learning gains are produced. Emerging work with children—for example, by Hijab et al. (2024) and Lozanovska & Xu (2013)—and recent calls to examine the "social life" of design methods (e.g., Stavholm et al., 2024) have begun to address this issue. Even so, we still lack a detailed understanding of exactly how co-design procedures and learning activities interweave in practice.

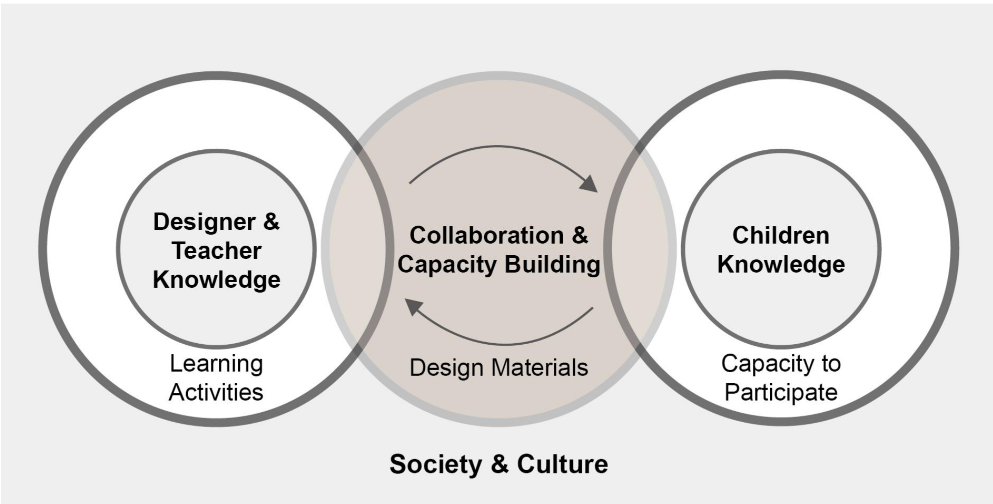

Figure 2.6. Participatory design collaboration system model (based on Drain & Sander, 2019).

2.5.2 Individuals, Teams and Systems

> "It is crucial that researchers be more precise about users' roles...who drives the process between sessions, with regard to interpretation, planning, and decision-making in the design process." (Halskov & Hansen, 2015, p.90)

In educational settings, the roles within co-design processes are typically categorised into adults and children. Teachers serve as both content specialists and the practitioners who bring the learning designs to life (Voogt et al., 2015). They contribute subject expertise alongside pedagogical knowledge shaped by their classroom experience. Section 2.2 examines this teacher-as-designer role in depth, outlining the capabilities educators need to participate meaningfully in design work.

Designer is another significant and multifaceted role that has garnered increasing attention in recent literature (Johnson et al., 2017; Lee, 2008; Lee et al., 2019a; Örnekoğlu-Selçuk et al., 2024; Taffe, 2015). Lee (2008) contends that the development of design participation should prioritize the "how" of design practice to prevent tokenistic involvement, rather than merely addressing the "why" or questioning the necessity of participation. Lee advocates for redefining professional designers' roles to effectively address emerging challenges. Similarly, Lee et al. (2019a) propose that redefining the designer's role and incorporating systematic planning in co-design processes can substantially enhance both outcomes and creative potential. Taffe (2015) identifies paradoxes in designer-end-user collaborations, noting that end-users often react negatively to outcomes intended for them, leading to the creation of hybrid designer/end-user roles that target alternative user groups. Johnson et al. (2017) emphasise that designers' mindsets and postures significantly influence problem identification and framing, yet these aspects frequently remain unacknowledged. Örnekoğlu-Selçuk et al. (2024) indicate the necessity for design students to engage in self-directed learning about co-design, suggesting that design educators bear the responsibility of preparing students for this emerging new role of design/designer. Consensus among researchers indicates that designers can achieve more comprehensive results through intensive problem-structuring activities within co-design processes (Lahti & Seitamaa-Hakkarainen 2005). But we can't ignore that the designer's role is dynamic, complex, and highly dependent on their educational background and context.

Expert is another role found in the literature that has been mostly used in the co-design (Noorbergen et al., 2021; O'Brien et al., 2016). Early studies by Lee (2008) finds a large-scale survey and interviews were conducted with the help of experts as in many civic education projects. These experts work collaboratively with designers to facilitate the integration of 'abstract' knowledge from experts and 'concrete' experiences from participants. Similar, Kleinsmann and Valkenburg (2008) describe how experts from within companies were brought in to conduct interviews when market researchers lacked specific knowledge, especially when interviewees used specialised jargon. In some cases, researchers have emphasised the direct involvement of behaviour change experts in the co-design process (Noorbergen et al., 2021). In others, Kittscha et al. (2024) highlight the practice of training "expert patients" to act as co-researchers and conduct interviews. In the field of public service design, there is a growing emphasis on shifting from an expert-driven process to one that enables users to be active and equal contributors to idea generation (Trischler et al., 2019). This transition reflects a broader trend in co-design towards democratising knowledge production and recognising the expertise of all participants, not just those with formal credentials.

An expanding body of research acknowledges children as vital contributors to design, describing them as co-creators or co-producers of their own learning experiences (Abbas et al., 2018; Bowler et al., 2021). Their participation can boost motivation by nurturing ownership, yield richer insights into the viewpoints and drivers of all stakeholders, and guard against adult assumptions about what children need (Martens et al., 2019). Nevertheless, researchers have also pointed out obstacles to meaningful involvement: children often lack deep process or domain expertise, power asymmetries can skew interactions, teachers' roles may shift in ways that unsettle established practices, and scepticism about the value of child-adult partnerships can persist (Martens et al., 2019). Druin (2002) maps children's possible positions in the design cycle on a spectrum—from passive users at one end to full collaborators with equal standing at the other (see Table 2.3). While the recognition of children as equal partners has gained traction in recent years, their participation is often still limited (Sharpe & Armellini, 2019). As Druin (2002) notes, despite being positioned as co-designers, the overarching challenge for children is that, in most roles, adults retain control over the process. Adults decide when and how to engage with children, as well as what aspects of their input will be considered. Particularly in the role of user, children are often observed or tested rather than initiating changes in the research methods themselves.

Table 2.3. Druin's categorisation of children's roles in design (adapted from Druin, 2002).

User	children can be observed, videotaped and/or assessed
Tester	children can be observed, assessed and/or be asked for feedback
Informant	children can be observed and/or be asked for input/feedback
Design partner	children can be considered to be equal stakeholders in the design process

The roles of adults and children in co-design can be summarised in Figure 2.7, based on the work of Yip et al. (2017). A clear understanding of the roles, responsibilities, and capabilities of all involved actors is essential for maintaining a balanced power structure and fostering effective teamwork (Bayerlein & McGrath, 2018). Defining boundaries based on expertise has been shown to positively impact collaborative work. For example, Albrahim (2018) found that establishing role boundaries facilitated smoother interactions and clearer communication among participants in a study. Studies also show that outdated or inaccurate assumptions about participants' roles—especially those assigned to designers and subject experts—create substantial barriers to collaboration. Drysdale (2019) lists these misconceptions among the most serious impediments to joint design work. Richardson et al. (2019), for example, interviewed academic and professional staff at a US university and discovered that many educators were unsure what designers actually do, at times mistaking them for evaluators. Instructional designers are further typecast as mere "techies" or learning-management-system administrators (Ritzhaupt & Kumar, 2015). When such stereotypes coincide with doubts about their value, the quality of the resulting designs can suffer—a problem Scoppio and Luyt (2017) also document.

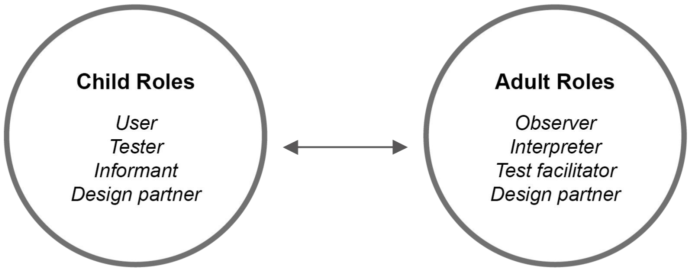

Figure 2.7. The complementary roles that adults and children play in the co-design (adapted from Yip et al., 2017).

The broader environment—the interconnected networks, structures, and contexts—significantly influences how individuals and teams engage in the co-design process. Anticoli and Toppano (2011) argue that an ontology is not only a socio-technical artifact but also a cultural one (Toppano, 2010). It reflects the underlying assumptions, values, beliefs, and perspectives of the community that created it. This perspective highlights the importance of understanding the cultural and social dimensions of co-design as integral to its effectiveness. In an East Asian context, Taoka et al. (2021) identify six barriers commonly encountered in co-design workshops across China, South Korea, and Japan. These barriers include: (1) difficulty in sharing ideas openly with individuals in higher hierarchical positions, (2) challenges in collaborating with strangers, (3) lack of trust in facilitators, (4) the need for group harmony, (5) ambiguous task assignments, and (6) the absence of a shared 'common language'. Furthermore, Taoka et al. (2021) emphasise that hierarchical barriers in co-design are not limited to organisational structures, such as superiors and subordinates, but also arise from social roles, where designers—often viewed as experts with specialised skills—may be perceived as having authority over non-designers. Recognising and addressing these barriers can help facilitators improve co-design practices in East Asian contexts.

In China, co-design is additionally shaped by long-standing cultural-institutional patterns that can dampen open participation and role fluidity. First, the high-stakes examination regime (anchored in the *Gaokao*) prioritises standardisation, efficiency, and risk-averse instruction, leaving limited curricular time and tolerance for exploratory, iterative activities typical of co-design; this exam orientation has been repeatedly identified as a system-level pressure that narrows pedagogical repertoires (Dello-Iacovo, 2009; Cheng & Hamid, 2025; Liu, 2023). Second, Confucian heritage norms of hierarchy, deference to authority, and harmony maintenance (e.g., avoiding confrontation/"loss of face") can discourage students, parents, and even teachers from challenging experts or proposing speculative alternatives in public forums (Hofstede, 2011; Sanger & Gleason, 2020; Yu & Eng Wong, 2025). Third, within inclusive education, policy advances have outpaced school-level capacity: the dominant "Learning in Regular Classrooms" model has faced persistent issues of uneven resourcing and teacher preparation, producing forms of integration without full participation—further constraining co-design as pedagogy (Deng & Poon-McBrayer, 2012). Taken together, these forces help explain why designer or expert authority is often presupposed, why child-led contributions may be muted, and why facilitators in China need explicit role negotiation, low-risk participation scaffolds, and assessment practices that recognise collaborative process as well as product.

2.5.3 Practices, Experiences, and Knowledge

Dewey argued that "thinking and acting are just two names for a single process—the process of making our way as best we can in a universe shot through with contingency," and that "knowledge is a by-product of activity: people do things in the world, and the doing results in learning something that, if deemed useful, gets carried along into the next activity (Steen, 2013, p.19)." This stance underscores the dual epistemic and social nature of co-design, where understanding is forged through hands-on, collaborative engagement. The empirical and theoretical work outlined in the next section therefore guides the present study's perspective on co-design.

Kyza and Agesilaou's (2022) multi-source case study—drawing on meeting transcripts, interviews, surveys, observations, and field notes—demonstrated that power sharing between teachers and researchers fosters mutual empowerment by widening access to information, resources, and expertise. As a result, teachers felt free to decide what and how to teach, while researchers could offer timely support. Although co-design was unfamiliar to these educators and not fully backed by existing school structures, they nonetheless valued the experience and reported substantial learning gains. Comparable insights appear in Wong et al.'s (2021) qualitative study, which examined how education professionals negotiate individual creative contributions and how material tools shape the collective design process. Their work highlights the intricate, often tension-filled dynamics of collaborative creativity and shows how appropriate co-design tools can mediate multiprofessional dialogue and help participants overcome constraints.

Other studies have put more emphasis on *collaboration*—the core activities of co-design—and its role in developing creative, socially supportive environments. Achieving successful collaboration, however, presents challenges, as it requires participants to understand each other, build trust, and develop rapport. Calvo and Sclater (2021) identify four key designerly conditions that support learning during collaboration in co-design settings:

1) ***Choreography and orchestration***, orchestration refers to the planning and coordination of socio-material conditions that support co-design situations. It involves balancing control and freedom within group dynamics, ensuring positive synergies and establishing power-balanced relationships to foster a safe, inclusive environment. This role requires researcher to possess socio-emotional skills, enabling them to navigate both the emotional state of the group and the subtleties of individual interactions.

2) ***Aesthetics***, the aesthetics of designerly activities amplify participants' experiences and activate their sensory symbolic constructs, which support their self-interpretation during co-design workshops. Aesthetics, encompassing physical environments, tools, techniques, and even sounds and lighting, helps establish a comfortable atmosphere that influences participant learning.

3) ***Playfulness***, playfulness is identified as a key factor in promoting high-quality learning experiences. It creates an inclusive environment by temporarily removing social constraints, allowing participants to engage in learning freely and without judgment, akin to the uninhibited playfulness of children.

4) ***Quality and quantity of participation***, the quality of participation is influenced by group dynamics and the nature of conversations. Building trust, fostering inclusiveness, and ensuring power-balanced relationships all contribute to meaningful participation. The number of participants also impacts the quality and depth of co-design outcomes, as a diversity of expertise and skills can enhance collaborative creativity and learning capabilities.

Calvo and Sclater (2021) also highlight that designers could intervene to improve the co-design process, particularly by supporting learning instead of paying attention to the resulting design products. Lowy et al. (2024) further explore factors contributing to successful co-teaching collaboration between educators and designers. Their study emphasises how design activities can create accessible collaborative learning environments for students with intellectual and developmental disabilities, supporting cognitive engagement, collaboration, and meta-cognition.

Studies by Lowy et al. (2024) underscore the importance of student interaction in design activities, where exchanging ideas, engaging in challenging learning tasks, and presenting design project outcomes are central to collaborative learning. Bowler et al. (2021) introduce their self-reflective journeys into co-design with youth and they advocate for the active role of children and youth in the co-design process. As Lozanovska and Xu (2013) note children's creativity and enthusiasm serve as valuable resources in the co-design process. Van Mechelen et al. (2018) point out reflection on the role of empathy in co-design raised awareness about children's role as designers, but translating this insight into practice requires time and effort. Those studies align with Dewey's (1958) promotion of an "empirical method," which encourages a reflective process of moving between primary experiences and secondary reflections to develop practical knowledge—knowledge grounded in practice and applicable in real-world contexts.

2.5.4 Communication, Cooperation, and Change

Dewey (1958) emphasised people's abilities to communicate and to cooperate as ways to jointly bring about positive change (Steen, 2013): "the heart of language is not 'expression' of something antecedent, much less expression of antecedent thought. It is communication; the establishment of cooperation in an activity in which there are partners, and in which the activity of each is modified and regulated by partnership (p. 179)." The literature reviewed reveals several characteristics and conditions that either support or hinder cooperation in co-design processes, which in turn affect the quality of decisions made. I draw on Paracha et al.'s (2019) suggestions for practitioners to structure this sub-section.

Effective communication

Effective communication mechanisms are crucial for ensuring collaboration and the inclusion of children during co-design workshops. Garcia-Melgar et al. (2022) highlight the importance of establishing these mechanisms, noting that communication should be regular, consistent, timely, appropriate, transparent, and strengths-based. They emphasise that while communication should be frequent, it need not be lengthy. Zechmeister-Koss et al. (2023) suggest that good communication and engagement skills are particularly beneficial for children whose parents have mental health issues. They also note that certain practices, such as using academic titles when addressing someone upon first meeting, may seem unusual in international contexts but are considered culturally appropriate in Austria. This highlights the need to consider cultural norms, professional relationships, and language characteristics when facilitating co-design processes.

In school, Kelly et al. (2019) observe that there will be instances where researchers have difficulty communicating with the school leaders. Van Mechelen et al. (2019) argue that limiting the number of materials used in co-design workshops, an approach meant to foster interdependence, did not always improve communication between team members. In some cases, it even led to process conflicts, such as disagreements over who should use a shared tool, like a pair of scissors. Further complicating communication in educational settings is the experience of students with autism. O'Rourke et al. (2023) highlight that these students often face heightened challenges in general education classrooms due to frequent transitions between classes, multiple subject teachers, varying peer groups, and unstructured time slots. These disruptions can exacerbate anxiety and sensory dysregulation, making communication between home, school, and external health professionals crucial for positive outcomes.

Building relationships

The relationship-building dimension in co-design focuses on the degree of social distance between adults and children, as well as the strategies employed to bridge this gap (Bowler et al., 2021). Bowler et al. (2021) note that researchers often maintain multiple roles with youth participants, such as serving as both educators and, in some cases, family friends—particularly given the challenges of recruiting children and youth for research. Zechmeister-Koss et al. (2023) identify several trust-facilitating practices that support relationship building in co-design settings. These include using name badges, familiarising oneself with participants'names before workshops, creating a welcoming environment (e.g., offering drinks and snacks to connect via shared pleasure), and providing information folders with details such as seating arrangements.

Building relationships with the entire family is especially significant in some cultural contexts. For instance, Bevan Jones et al. (2020) emphasise that engaging with the families of Maori and Pacific youth helps account for the broader cultural and social context in the delivery of interventions. Similarly, Abbas et al. (2018) suggest involving parents or caregivers in providing feedback on character designs alongside their children. They found that children are often more comfortable and willing to offer detailed feedback when accompanied by a familiar adult. Additionally, including caregivers' perspectives ensures a more inclusive approach to co-design by incorporating a broader range of stakeholder viewpoints.

Ethical considerations also play a crucial role in relationship building. Thabrew et al. (2018) highlight the importance of addressing ethics and review board requirements, including clear communication about the duration of processes and adherence to project briefs. Conflict and tension, often related to power dynamics, may arise within co-design groups. These challenges are particularly pronounced if users have had previous negative experiences with researchers, underscoring the importance of trust and respectful engagement in fostering successful relationships.

Cooperation mechanism

In co-design processes, designers invest significant effort into structuring collaboration to ensure meaningful engagement among participants (Durall et al., 2019). Durall et al., (2019) emphasise the key aspect of effective collaboration is fostering horizontal relationships that allow various parties to share information and learn from one another on equal terms. The cooperative inquiry method exemplifies this principle by defining the roles children can take on during different phases of the design process, creating intergenerational teams that emphasise mutual learning

(Druin, 2002).

The involvement of schools in co-design processes often depends on their organisational culture. Parnell et al. (2008) found that schools with a pre-existing consultative approach were more likely to integrate design into their programmes, such as treating it as part of their citizenship curriculum. Collaboration with participation consultants provided these schools with tools to adopt more consultative practices. However, other schools expressed initial hesitancy about involving students in the design process, citing challenges such as the logistics of managing large groups of children, uncertainty about how to involve them effectively, and fears about losing control of the process. Organisational or school support play a crucial role in facilitating successful co-design processes. Voogt et al. (2016) highlight that proactive organisational support—such as planning meetings, organising venues, and coordinating schedules—is often provided by researchers or team coordinators in close cooperation with the design team. They further emphasise the pivotal role of school leadership in enabling teams to work effectively and produce sustainable outcomes. The active involvement of school leaders was identified as the most significant factor in promoting the success of co-design initiatives.

In addition to organisational challenges, structuring activities within co-design contexts also presents unique considerations. Van Mechelen et al. (2019) discuss the use of inter-group competitive mechanisms in co-design activities, where design teams compete against one another. To ensure inclusivity, they emphasise the importance of recognising individual contributions (e.g., awarding design certificates) so that all participants feel a sense of accomplishment, not just members of the winning team. However, Brondino et al. (2015) caution that gamification in co-design should prioritise cooperation to remain aligned with the principles of partnership and collaboration. They propose limiting competition within groups and providing rewards that foster “intra-group positive interdependence” to promote collaboration while still satisfying relatedness needs. Hurley et al. (2018)

Idea-generation

Research on how teenagers develop ideas in co-design reveals that the best designs often emerge from individuals who generate the highest number of ideas overall (Read et al., 2021). Co-design with children, while challenging for researchers, designers, and children alike, pushes all participants out of their comfort zones and fosters a mutual learning experience that serves as the foundation for idea generation (Ghaziani, 2021). This collaborative dynamic not only encourages creativity but also enables the exchange of new knowledge between stakeholders.

Contemporary designers are increasingly expected to adopt the role of facilitators in co-design processes, acting as bridges among individuals from diverse disciplines to enable creative idea generation (Örnekoğlu-Selçuk et al., 2023). As Manzini (2015) argues, this facilitator role should go beyond mere administrative tasks, such as organising "post-it design" sessions where designers passively collect and visualise participants' ideas. Instead, designers should actively engage in meaningful "Design Conversations," as outlined by Dorta et al. (2011), which involve using verbal communication, gestures, and visual representations to foster efficient collaborative ideation with non-designers.

Moreover, an effective co-design setup often includes involving representatives of the actual target audience. For instance, Hurley et al. (2018) suggest incorporating users, such as parents, in the idea generation process for programmes designed to meet their needs. Also, the success of co-design relies on careful planning and facilitation. Sanders and Westerlund (2011) provide a general framework for co-design practices, emphasising key considerations such as participant recruitment, sensitising participants to encourage creative thinking, preparing materials to evoke idea generation, and reflecting on the outcomes post-event.

Product co-prototyping

Prototyping processes have evolved to become more open, collaborative, and discursive, offering greater accessibility and transparency across various disciplines and making them more applicable to broader social discourse (Kimpel et al., 2015). Sanders et al. (2014) define prototypes as physical manifestations of ideas or concepts, which can range from rough representations that convey only the core idea to more refined versions that closely resemble the final product. This spectrum of prototyping plays a crucial role in co-design, facilitating the gradual development of concepts into tangible outcomes.

Unlike the traditional role of prototyping—primarily used for testing and refining finalised designs—the growing emphasis on end-user participation throughout the design process has redefined prototyping as an iterative and collaborative tool. Iterative prototyping fosters collective creativity and supports the exploration of conceptual designs, enabling continuous feedback and adaptation (Lee et al., 2019b). Stappers (2014) categorises prototyping into four distinct roles: (1) testing physical hypotheses, (2) engaging with theories and the real world, (3) envisioning non-existing situations to drive change, and (4) provoking dialogue within groups. These roles illustrate the versatility of prototypes as tools for ideation, exploration, and communication.

In co-design contexts, prototypes serve multiple purposes. Co-designers create prototypes to visualise their ideas and solicit feedback from other stakeholders, designers use them as tools for iterative development, and end-users interact with prototypes during evaluative research to provide insights for further refinement (Sanders et al., 2014). Similarly, Lee et al. (2019b) emphasise that prototypes empower participants to express their intentions and actively modify designs during co-design sessions. Dodero et al. (2014) found that children effectively engaged with and produced prototypes during short-term gamified co-design activities, demonstrating the accessibility and adaptability of prototyping for younger participants.

To further enhance the evaluation of evolving prototypes, Brink et al. (2024) advocate for a developmental evaluation approach. This method supports ongoing assessment throughout the design process by encouraging evaluators to co-create and iteratively refine prototypes, rather than simply judging a finalised product. This continuous feedback loop aligns with Sanders et al.'s (2014) view that prototypes are most effectively utilised after identifying a design opportunity, serving as dynamic tools for exploration and collaborative development.

Participation and co-creation

Comparing co-creation approaches across different contexts presents significant challenges due to the diversity of settings in which they are applied. However, the foundational principles of open innovation and participatory design have been instrumental in integrating and promoting co-creation as a participatory strategy for addressing complex problems (Jones & Kijima, 2018). Greenhalgh et al. (2016) identified four distinct health initiatives that, despite their differences, shared core principles of power-sharing, reciprocity, and mutual learning among participants, underscoring the universal relevance of these values in co-creation processes.

In educational settings, the impact of student participation in design processes has been mixed. Parnell et al. (2008) reported that the influence of student involvement on design outcomes was often minor or difficult to measure. In contrast, Mäkelä et al. (2018) found that student participation significantly enhanced design quality by helping to prevent the implementation of overly radical changes. Moreover, the involvement of teachers was deemed essential for providing in-depth pedagogical knowledge, which further refined the design process. Similarly, Glumac et al. (2022)

emphasised the importance of actively engaging youth in shaping the school environment and extracurricular programmes. Their study revealed that participating schools were challenged to mobilise their communities to develop sustainable co-creation practices and foster a culture of resilience and student participation in decision-making. Ghaziani (2021) highlights that innovative architects acknowledge the impossibility of designing future-oriented schools in isolation. They emphasise the necessity of involving school users in the design process, viewing children as the primary "addressees" of educational spaces and considering instruction as the "soul" of the building, reflecting a focus on the joy of learning and motivation to achieve (Walden, 2009). Matching methods and materials to children's abilities is also seen as critical for maximising the outcomes of co-creation sessions (Ghaziani, 2021). Additionally, Bowler et al. (2021) stress the importance of transparency in youth participation, advocating for a structural understanding of partnerships. They call for a deeper examination of how designers—typically adults—collaborate with less experienced community members, often youth, to create products, processes, pedagogies, or programmes.

Dewey conceptualised knowledge as instrumental, emphasising its role in exploring alternative futures, fostering communication and cooperation, and driving positive change. These core themes—practice, experience, knowledge, communication, cooperation, and change—through his concept of inquiry, are deeply embedded in co-design practices, making Dewey's philosophy highly relevant to discussions on co-design. Dewey advocated for the organisation of joint inquiry processes, where individuals collectively explore, discuss, and define problems while collaboratively developing and evaluating potential solutions. In this a process of inquiry, the goal is not to generate universal or abstract knowledge that merely reflects external reality but to create a participatory environment where people can explore, learn, and bring about change in a desired direction (Steen, 2013).

2.6 Reprise

This chapter has provided a comprehensive examination of the core areas central to this thesis, synthesising the overlapping and at times fragmented literature on design (including the nature, processes, and the knowledge and skills of teachers as designers), pedagogy, materiality, and co-design within the educational context. It foregrounds the conceptualisation of teaching as a form of design, revealing how educators navigate multifaceted challenges, integrate inclusive pedagogical strategies, and harness innovative tools to foster accessible learning environments. The review synthesises design principles for TG with insights from participatory design, advocating for the involvement of PVI as co-designers to democratise knowledge creation and enhance design relevance. It outlines how co-design processes transcend traditional roles of teachers, designers, and experts, promoting collaborative learning and mutual growth. The examination of materiality underscores its ontological and sensory dimensions, framing materials as cognitive extensions that mediate learning experiences. To summarise, co-design emerges as a pivotal activity in ensuring high-quality learning and teaching. While there is growing recognition of educators' design approaches, further studies are required to explore design practices, particularly in diverse cultural contexts, to strengthen the evidence base.

The reviewed literature also identifies numerous challenges faced by designers and educators, including limited time, expertise, and practical knowledge, which critically influence decision-making processes. Despite increasing interest in co-design, there remains a paucity of studies examining in-situ design practices with VIC and the decision-making processes of key actors, particularly within educational context. While the chapter provides a robust foundation, it exposes several critical research voids:

- ***Empirical Deficit in Co-Design with VIC***: While co-design is acknowledged as a valuable approach for fostering mutual learning and creating inclusive educational materials, there is limited empirical evidence on its implementation with VIC. Studies like those by Van Mechelen et al. (2019) highlight the potential of co-design but do not extensively document its outcomes for VIC in structured educational environments. Similarly, Hijab et al. (2024) and Lozanovska & Xu (2013) call for more detailed examinations of co-design processes, particularly focusing on how mutual learning is operationalised. The Drain & Sander (2019) participatory design collaboration system model provides a theoretical framework but lacks direct applications to VIC-specific co-design.

- ***Limited Cultural Contextualisation***: Most research on TG and co-design stems from Western institutions, as noted by Williamson (2019), who ties the origins of inclusive design primarily to the UK and US. The underrepresentation of research in Asia and South America is evident, with Rong et al. (2025) identifying this gap and advocating for the expansion of TG studies to developing regions. The study by Gupta et al. (2021) illustrates the potential influence of cultural differences on co-design but is geographically confined to a single community in India, leaving broader regional insights unexplored.
- ***Technological Integration Challenges***: Advanced methods such as interactive audio-tactile graphics (Melfi et al., 2020) and augmented reality (Thevin et al., 2018) have demonstrated potential in experimental settings but have not been widely adopted in classrooms. The Zeng et al. (2012) study on refreshable tactile displays highlights cost barriers, with systems often priced between $2,000 and $50,000, making them inaccessible in many educational contexts. The integration of tools like 3D printing for tactile materials remains in its infancy, with Barvir et al. (2021) and Gill & Pawluk (2022) indicating that while these tools are promising, they demand substantial teacher training and institutional investment.
- ***Pedagogical Complexity in Design***: The intricate dynamics of co-design teams, particularly the roles and power balance among educators, designers, and visually impaired participants, remain poorly articulated. Studies such as Taffe (2015)

identify challenges in designer-end-user collaborations but do not specifically address VIC. Similarly, Lee (2008) stresses the need to redefine professional roles in co-design, yet practical insights into achieving this in educational settings are sparse. Voogt et al. (2016) acknowledge educators' dual roles as subject-matter experts and co-designers but do not delve into the implications for VIC-specific design.

- ***Materiality's Underexplored Potential***: The concept of materiality as a dynamic and evolving force in education, as discussed by Ingold (2007) and Ellsworth (2005), lacks empirical validation in VIC learning. While tactile materials are recognised as cognitive tools (Hutchins, 1995), their systemic integration into pedagogical strategies for VIC is underexplored. The studies by Shove et al. (2012) and Engeström (2001) suggest the need for longitudinal research into how material properties influence learning outcomes over time. The interplay between sensory and cognitive properties of materials, as theorised by Merleau-Ponty (2004) and Pye (1968), is yet to be sufficiently examined for its practical implications in VIC education.

To close these gaps, this study adopts an integrated lens that considers the interaction of people—VIC, teachers, and designers—alongside learning processes and pedagogical frameworks. Participants were recruited from the Chinese context (see details in Chapter 4) to explore how culturally associated factors influence the design decision-making processes of key actors. This thesis, therefore, seeks to bridge the gap between design, pedagogy, and the lived experiences of VIC in China, contributing to a broader understanding of how co-design can be a transformative pedagogical tool. This research also aims to evaluate the potential benefits of co-design for enhancing VIC learning and its implications for teachers' future practices. The next chapter explains how CHAT provides the study's analytical foundation.

3. Theoretical Framework

This chapter introduces the theoretical framework, explaining why CHAT was chosen as the guiding lens, detailing its core principles, advantages, limitations, and its multifaceted role throughout the research process.

3.1 Introduction

Chapter 2 laid the groundwork for this study by reviewing the pertinent literature. Building upon that foundation, the present chapter outlines the theoretical lens guiding the research—the third generation of CHAT. It first sketches Vygotsky's sociocultural theory and traces the evolution of CHAT to clarify its origins and principal constructs. This historical perspective situates the framework within a broader theoretical landscape, providing a basis for its adoption in this study. Subsequently, the rationale for employing CHAT is discussed, detailing its suitability and application within the context of this research. Following this, the chapter delves into the core theoretical concepts of CHAT, contextualising their relevance to the research setting by drawing on examples from existing literature. This exploration underscores the framework's capacity to analyse complex, collaborative processes in educational and design contexts. It closes by critiquing CHAT's limitations, describing the measures taken to mitigate them, and detailing the framework's multifaceted role across the thesis as a versatile analytic tool.

3.2 The Vygotskyan Heritage

The work of Vygotsky has profoundly influenced contemporary thinking on children's education. He argued that the mind can only be understood by tracing its "genetic transformations"—the developmental history through which cognition emerges and changes (Wertsch, 1990). Cognition, he insisted, is dialectical: the environment shapes individuals even as individuals shape their environment. What matters, therefore, is the dynamic interplay itself; studying only its finished products reduces research to cataloguing "fossilised behaviour" (Vygotsky, 1978). Vygotsky's approach is characterised by three central themes: (1) understanding the mind through its developmental changes, (2) higher mental functions first appear in social interaction, and (3) those functions are mediated by cultural tools and signs.

Vygotsky explored psychological processes during periods of transition by investigating disruptions and interventions. A notable cross-cultural study analysed the psychological transformations of Central Asian peasants during collectivisation, revealing that mental processes were directly shaped by human activities and cultural forms (Cole, 1988). On an individual level, Vygotsky studied children to understand how reactions emerge, take shape, and changes after it is formed (Vygotsky, 1978). He concluded that child development is a complex dialectical process between the child and their social environment, with the latter providing support to enable independent mastery of skills previously learned through collaboration.

The second theme in Vygotsky's framework is the social origin of higher mental functions, which initially occur on the social plane before being internalised on the individual level, "actual relations between human individuals" (Vygotsky, 1978, p.57). He described internalisation as the internal reconstruction of external operations, particularly through the development of speech. Children transition from external speech to egocentric speech and eventually to inner speech—a process that reflects a series of developmental milestones. According to Vygotsky, inner speech retains a quasi-social nature, serving as a dialogue within the individual and sustaining the social roots of mental processes (Wertsch, 1990).

The third theme emphasises the mediation of higher mental functions by tools and signs, which fundamentally shape human activity. Vygotsky studied speech as a particularly powerful mediational tool, demonstrating how children move from direct physical responses to speech-mediated responses, eventually developing inner speech.

He noted that “the child begins to perceive the world not only through his eyes but also through his speech...the immediacy of “natural” perception is supplanted by a complex mediated process” (Vygotsky, 1978, p.32). This mediated process restructures psychological functioning, regulating attention and fostering new culturally informed forms of cognition. Tools, signs, and cultural artifacts not only shape human perception but are also recreated and transformed by individuals, underscoring the dynamic interplay between humans and their cultural environment.

> “The child’s memory not only makes fragments of the past more available, but also results in a new method of uniting the elements of past experience with the present” (Vygotsky, 1978, p.36).
>
> “It may be said that the basic characteristic of human behavior in general is that humans personally influence their relations with the environment and through that environment personally change their behavior, subjugating it to their control” (Vygotsky, 1978, p.51).
>
> “Learning is more than the acquisition of the ability to think; it is the acquisition of many specialized abilities for thinking about a variety of things” (Vygotsky, 1978, p.83).

Vygotsky distinguished learning from development, arguing that learning propels development forward. Every child, he suggested, has an “actual” level of development alongside a further capacity for growth within a particular domain. This insight carries important educational implications: instruction should be scaffolded to close the distance between what a child can presently do and what they are capable of achieving with appropriate support.

3.3 Mediation

Mediation sits at the core of Vygotsky’s account of cognition. In joint activity, adults furnish children with material and symbolic tools which, once internalised, enable more complex psychological operations (Karpov & Haywood, 1998). Vygotsky’s writings—formative of the first generation of Cultural-Historical Activity

Theory—pivot on the idea of “cultural mediation” (Vygotsky, 1978, p. 40), rejecting behaviourist claims that behaviour is merely a direct reaction to external stimuli. Instead, he argued that human action is always channelled through materials and tools that reshape the object, or purpose, of activity. Figure 3.1 depicts this mediational schema, underscoring that learning is intrinsically social: individuals act within a cultural milieu, deploying shared tools and signs to achieve object-oriented goals.

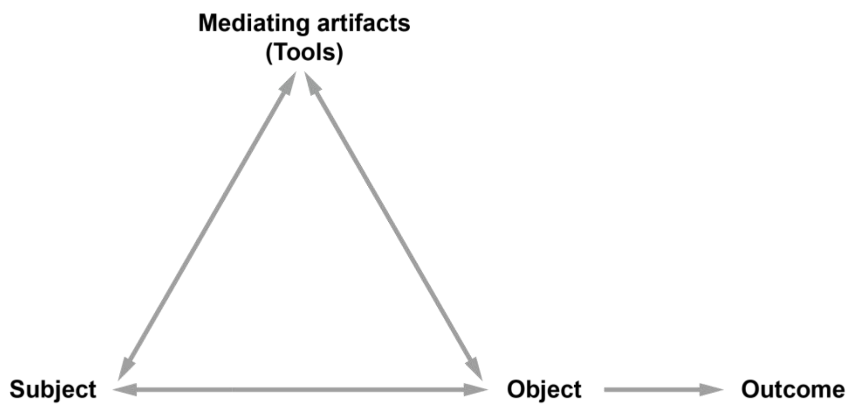

Figure 3.1. Vygotsky’s model of mediated action: representation of the first generation of CHAT (adapted from Vygotsky, 1978).

Vygotsky distinguishes two kinds of mediating artefacts. Primary, material tools—such as computers, pens, books, or machines—operate externally, shaping the object of an activity and extending human action much like a stick extends one’s reach (Vygotsky, 1978). In design settings, such artefacts can become “a form of thinking with...hands” (Boland et al., 2008). Secondary tools, or signs—language, symbols, and other social conventions—mediate inwardly as psychological instruments. These signs reorder behaviour beyond purely biological development, fostering “new forms of a culturally based psychological process” (Vygotsky, 1978, p. 40).

Vygotsky (1978) connected his principle of internalisation-externalisation to the difference between physical tools and psychological signs. These processes form a continuous loop rather than a simple opposition: outward actions are gradually reconstructed inwardly, and the resulting mental structures can re-emerge in social interaction (Fjeld et al., 2002). Internalisation begins in joint activity, where individuals adopt ideas and practices encountered in collaboration; those newly formed inner resources then guide future exchanges. In a design session, the pendulum swings outward again—externalisation—when participants co-frame a problem and articulate concepts that can be turned into concrete solutions (Engeström, 2015). Vygotsky's famous handkerchief anecdote illustrates the mechanism. By tying a knot to remember a task, a person "constructs the process of memorising" through an external prop (Vygotsky, 1978, p. 51). If the handkerchief is used for counting, it functions as a material tool; when the knots are mentally linked to items to be recalled, they become symbolic cues that organise thought (Bakhurst, 2009).

3.4 Activity

Vygotsky treated purposeful human activity as the cornerstone of psychological explanation, yet he did not spell out its full complexity. Although his ideas strongly shaped educational theory, Engeström (1987, 1999, 2001) argues that Vygotsky's framework remains centred on the individual, giving insufficient weight to the social dynamics of action. Because of this individual focus, the model struggles to account for the intricacy of contemporary, distributed forms of activity (Engeström, 1999).

To address this limitation, Leont'ev (1978) tackled this issue by moving the analytical focus from solo actions to collective activity systems, inaugurating the second generation of CHAT. He embedded action in its sociocultural milieu, demonstrating how collaborative, societal, and community arrangements condition human behaviour. Leont'ev proposed a tripartite structure of activity, consisting of unconscious operations involving tools, conscious goal-directed actions, and higher-level activities that are object-oriented and driven by motives. Engeström (1987) further developed Leont'ev's ideas by transforming them into a graphical model known as the activity system (Figure 3.2), extending Vygotsky' s mediation model with the social mediators of rules, community, and division of labour. These elements mediate and influence the interaction of subjects with object-oriented activities, guiding the pursuit of intended or unintended outcomes (Engeström, 1999).

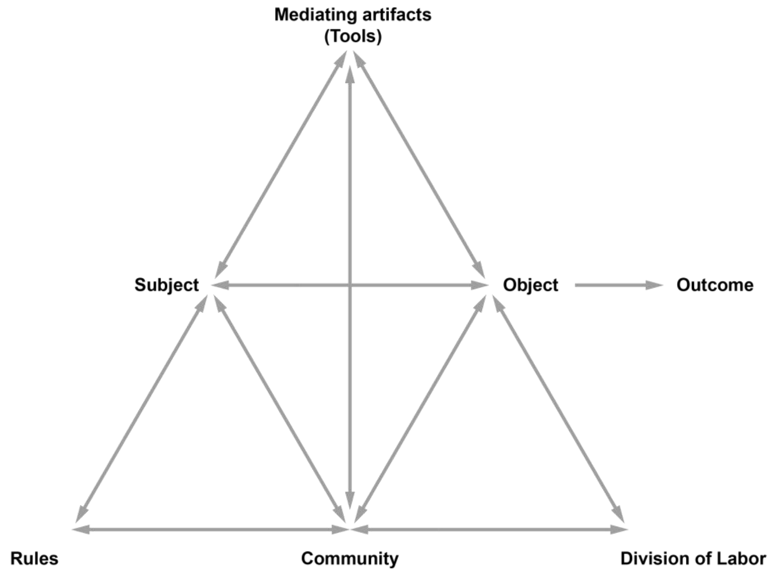

Figure 3.2. The second generation activity system (adapted from Engeström, 1987, p.78).

Within Engeström's model, every activity system is entwined with the material practices and socioeconomic arrangements of its culture—an aspect largely missing from Vygotsky's original triadic scheme (Engeström, 1999; Wertsch, 1981). Building on this insight, Leont'ev positioned thought and cognition squarely inside social life, situating them amid prevailing production methods, social relations, and individuals' intentions in particular contexts. His classic example of the "primeval collective hunt" (Leont'ev, 1981, p. 210) illustrates the point: a single action, such as a beater driving game toward others, has its own immediate aim, yet it also contributes to the overarching collective purpose of securing food. Operations, in turn, are shaped by the tools available and the prevailing conditions, thus feeding into the broader activity. This logic underpins the three-tier hierarchy of human functioning (Bozalek, 2015; Engeström, 1987): collective activities are propelled by object-related motives at the top level; actions are organised by specific goals at the mid-level; and operations, often routinised, respond to current tools and conditions at the foundational level.

3.5 Third-Generation CHAT

Vygotsky's (1978) exploration of higher mental functions at the individual level—and Leontiev's subsequent extension of this work to collective activity (Engeström, 1987)—paved the way for addressing diversity and cross-tradition dialogue. Building on these foundations, Engeström (2001) formulated a third generation of Cultural-Historical Activity Theory that examines social practice through multiple perspectives and through the interplay of several interacting activity systems. The crucial shift is in the unit of analysis: instead of a single activity system (second generation), the spotlight falls on a network of systems that pursue a partially shared object (Engeström & Sannino, 2010; see Figure 3.3). In this configuration, collaboration is directed toward an object that is continuously shaped by mediating artefacts and social structures. Engeström (2001) further conceptualised the object of shared activity as evolving through three stages: from an initial, unreflected state of material (Object 1), to a collectively constructed, meaningful object (Object 2), and finally to a potentially jointly constructed object (Object 3). This dynamic process frames the object not as a fixed target but as one that shifts in response to the subjects' actions, which are often transient and context-dependent.

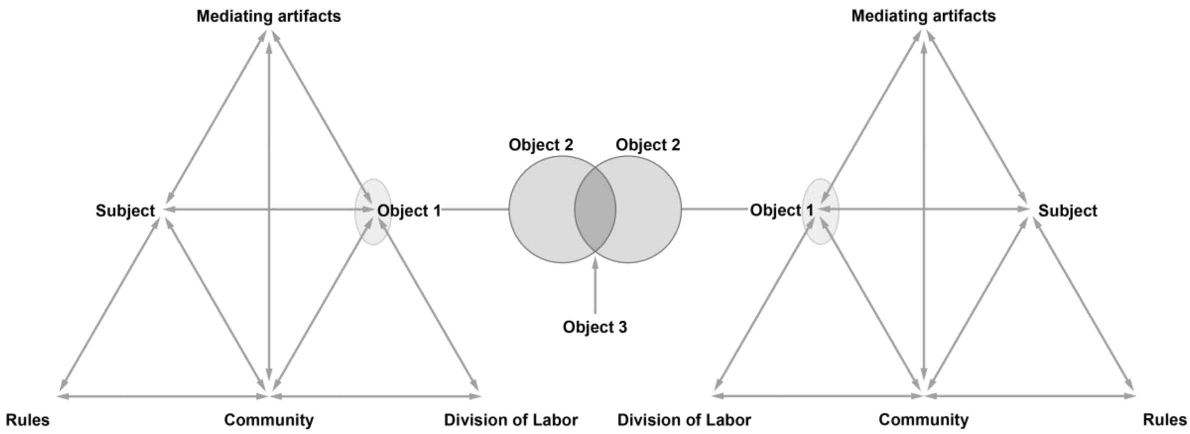

Figure 3.3. The third generation of CHAT: a pair of interacting activity systems as the basic unit of analysis (adapted from Engeström, 2001, p.136).

From a CHAT perspective, learning is seen as a process in which contradictions within and between activity systems emerge and are creatively, though partially, resolved (Ke et al., 2023). Such partial resolutions give rise to an enlarged mode of activity, a qualitatively new “thirdness” (Peirce, 1992). This thirdness is not a simple compromise or blend of opposing forces; rather, it creates something genuinely novel that propels the activity system’s transformation (Engeström & Sannino, 2011). Engeström labels this dynamic expansive learning: learners fashion new practices by recognising and working through the contradictions embedded in their activity (Engeström, 1987; Engeström & Sannino, 2010). Expansive learning emphasises the process of learning something that does not yet exist, where participants work together to reconfigure practices in response to systematic contradictions (Engeström & Sannino, 2010).

The third generation of CHAT has proven particularly useful in examining partnerships between different activity systems in the contexts of learning and teaching (Anastasiou, E & Hajisoteriou, 2022; Bal et al., 2021; Hancock & Miller, 2018). It has been widely applied in school system research, where stakeholders from diverse fields—such as teachers, parents, researchers, students, and professional partners—collaborate to create new forms of practice or co-develop services for use in educational settings (Daniels, 2004).

3.5.1 Rationale for using CHAT

Since its inception, scholars using CHAT have explored the experiences of individuals with disabilities. Vygotsky, who helped establish the Soviet Union’s Institute of Defectology, pioneered inquiries into children with learning difficulties and developmental disorders. Together with his colleagues, he focused on reshaping the social settings surrounding these children so they could regulate their own behaviour and alter their environments. Rejecting the prevailing charitable or deficit-oriented views, Vygotsky framed disability as a condition embedded in specific socio-historical and spatial contexts (Bal, 2018; Vygotsky et al., 1993). His perspective highlighted the agency of CwD: rather than merely measuring their performance on preset tasks, he examined how they adapted situations, employed auxiliary tools, and drew on assistance from more capable partners to solve problems (Vygodskaya, 1999). Within this framework, individuals with disabilities are understood as active protagonists, able to shape both their actions and their immediate surroundings (Vygotsky, 1978).

Vygotsky et al. (1993) conceptualised disability as a learning difference rather than a deficiency, arguing that disability is a bio-cultural phenomenon. It is not an individual property but rather a matter of the cultural context in which both material and ideal cultural artifacts play a role in shaping opportunities and outcomes. As Vygotsky stated:

> "Physically, blindness and deafness will still exist on earth a long time. A blind person will remain blind and a deaf person deaf, but they will cease to be handicapped because a handicapped condition is only a social concept; a defective condition is an abnormal extension of blindness, deafness, or muteness. Blindness by itself does not make a child handicapped; it is not a defective condition, an inadequacy, abnormality, or illness. Blindness becomes these things only under certain social conditions of a blind person's existence. This is a sign of the difference between his behaviour and the behaviour of others." (Vygotsky et al., 1993, pp. 83–84).

Vygotsky regarded disability as a two-sided condition: the loss of one faculty can be counterbalanced by the heightened development of other higher mental functions. He argued that physical or cognitive limitations may be mitigated by cultivating new abilities (Smagorinsky, 2012). Trent et al. (1998) extended this idea, framing disability within its socio-historical context and employing CHAT to interpret special-education issues. Later studies demonstrate how CHAT can guide interventions for students with disabilities, helping to address behavioural difficulties, reduce racial disparities, and foster more inclusive educational environments (e.g., Artiles, 2019; Smagorinsky, 2012; Vygodskaya, 1999).

This study adopts CHAT as its primary analytical lens for exploring how teachers and designers jointly shape learning materials for VIC and the forces that influence those choices. CHAT frames human action as system-based and socially embedded (Nardi, 1996), a stance that resonates with the inherently collaborative nature of design. By attending not only to the immediate participants—teachers, designers, and other experts—but also to the surrounding sociocultural fabric of rules, communities, and mediating artefacts, CHAT enables a comprehensive view of co-design practice. This broader perspective is crucial because most research on design's social dimensions has focused on fine-grained partner interactions while neglecting the wider cultural and historical landscape (Lefstein et al., 2020). Using CHAT thus allows this thesis to conceptualise learning activities as object-driven, tool-mediated, and collective endeavours.

The decision to use CHAT as the theoretical framework is further reinforced by the expansive nature of the learning activities in this study. Unlike traditional learning theories that focus on the acquisition of pre-determined knowledge and skills, expansive learning encourages the creation of novel solutions that lead to transformations in the activity itself (Engeström, 2001). Embedded within complexity-oriented systems theory, CHAT allows researchers to investigate the dialectical interplay between activity systems and their surrounding contexts (Crawford & Hasan, 2006). Consequently, it offers a robust framework for analysing how teachers collectively depart from established routines and develop new forms of practice in professional development and educational settings.

3.5.2 Key theoretical principles

This section clarifies the core, interconnected principles of CHAT and demonstrates their significance for the current study.

Contradictions and historicity

A core tenet of CHAT is that contradictions propel change (Engeström, 2001). These contradictions are not simply disagreements or surface-level tensions; instead, they are “historically accumulating structural tensions within and between activity systems” that drive “innovative attempts to change the activity” (Engeström, 2001, p.137). Cole and Engeström (1993, p.8) further emphasise that “activity systems are best viewed as complex formations in which equilibrium is an exception and tensions, disturbances, and local innovations are the rules and the engine of change.” Instead of merely signalling problems, contradictions energise the transformation of practice. Because they are rooted in history, contradictions are not directly visible; they become apparent only when voiced or enacted (Engeström & Sannino, 2011; Hatch, 1997). Crucially, their transformative power is realised only when the individuals who experience them recognise and deliberate upon them (Murphy & Rodriguez-Manzanares, 2008).This is particularly significant in this thesis, as the literature suggests that tensions often arise due to differing understandings of the roles and expectations of key actors (see section 2.5.4).

Engeström and Sannino (2011) classify contradictions into four levels: (a) Primary contradictions, which occur within components of an activity system. For example, in this study, a tension might arise within the “rules” component if a specific pedagogic approach emphasised by the learning and teaching strategy conflicts with the internal quality assurance rules of the organisation. (b) Secondary contradictions, which arise between different components of an activity system, such as contradictions between subjects and objects or between subjects and tools. (c) Tertiary contradictions, which occur between the objects of two activity systems. For instance, in this study, tensions may emerge between teachers’ historic approaches to learning design and the objectives of a newly introduced design activity. Resistance to new work patterns may arise from ingrained habits, necessitating modifications to the new activity model. (d) Quaternary contradictions occur between a central activity system and an external, interconnected activity system. For example, in this study, a designer might advocate for the inclusion of reflective learning activities in a co-design process, but teachers from another activity system may question their relevance to specific subject areas, leading to conflicts and misunderstandings during collaboration.

To fully understand contradictions, it is essential to consider their historical context. Historicity is also a core tenet of CHAT, suggesting that the challenges and potential of an activity system can only be understood by examining its development over time (Engeström, 1999). As Engeström and Sannino (2021) state, "history is always present in human activity. Layers of historically earlier forms of the activity can be both constraints and resources. They persist in routine actions, in ways of thinking, in material artefacts and in rules." This perspective underscores the importance of considering local histories, accumulated experiences, and established practices when analysing activity systems. Ignoring historicity risks producing explanations that are arbitrary or disconnected from the true nature of the phenomenon (Engeström & Sannino, 2021).

Multi-voicedness and boundaries

In CHAT, every activity comprises individuals who bring their unique experiences, viewpoints, identities, roles, and interests into the system (Engeström, 2001). This socio-cultural diversity, described by Kagawa and Moro (2009) as potentially complementary, is conceptualised in CHAT through multi-voicedness. Engeström (2008) highlights that understanding these varied perspectives requires crossing learning boundaries—listening to others' challenges and viewpoints, asking probing questions about underlying issues, and collaboratively working toward mutually beneficial resolutions (Clifford, 2022). While multi-voicedness can introduce challenges and confusion, it is also a key driver of innovation.

When multiple activity systems interact, as in the case of this thesis, the complexity and multi-voicedness intensify. For different activity systems to collaborate fruitfully, participants must create shared “in-between” arenas that bridge long-standing divisions rooted in distinct practices, professional identities, terminologies, and areas of expertise (Kali et al., 2018). Such boundaries described by Akkerman and Bakker (2011, p. 133) as “sociocultural differences leading to discontinuity in action or interaction”. These boundaries are fluid, marking territories or communities where knowledge, authority, and degrees of participation differ, thereby reflecting underlying power relations (Bernstein, 2000). Over the years, education researchers have drawn on the boundary concept to investigate how institutions and their communities engage and cooperate across these divides (Suchman, 1993; Wenger, 1999). Two critical elements in this discourse are boundary crossing and boundary objects, which serve as theoretical underpinnings in CHAT and communities of practice (Akkerman & Bakker, 2011).

Boundary crossing describes the movement of people between distinct settings, where they must learn to operate in unfamiliar contexts (Suchman, 1993). Individuals who work along these edges are variously called boundary crossers, boundary spanners, or brokers (Akkerman & Bakker, 2011). In this study, the designer is required to cross the boundaries between the cultures of education and schooling—a process that is inherently challenging. Boundary crossing involves establishing interactions across collaborative sites that differ in norms, goals, tools, and practices (Bakx et al., 2016). Dialogue, negotiation, and joint reflection at these junctures can give rise to new, hybrid ideas and practices (Akkerman & Bakker, 2011). However, fostering participation and collaboration in education remains a persistent challenge, as moving away from individualised practices often requires substantial effort from boundary crossers.

Boundary objects—artifacts that operate at the intersection of different practices—function as critical connectors across professional domains (Star, 2010). In the context of this study, partially developed learning environments and design prototypes exchanged among participants act as such bridging devices (Kali et al., 2018). They help actors recognise, align, and integrate their distinct forms of expertise, ultimately supporting the production of jointly meaningful outcomes. Because teachers and designers hold memberships in multiple communities, they are well positioned to mediate these crossings, easing movement between research, instruction, and design. Accordingly, this thesis uses the notion of boundary crossing to examine how participants from disparate settings collaborate on a shared object and how their respective competencies shape that object.

Possibility of expansive learning

Expansive learning constitutes another key principle within CHAT, offering a route for reshaping both the object of an activity and the participants themselves. Engeström (2016) later developed this notion into a comprehensive theory. Although the structural tensions that build up inside and between activity systems are crucial, Engeström and Sannino (2010) contend that these contradictions are not the only drivers of change. Expansive learning arises when individuals and their collectives surface, interpret, and negotiate these tensions, thereby questioning existing arrangements, forging new cultural practices, and generating innovative ideas that redefine the shared object (Engeström, 2001, 2011).

Expansive learning encourages participants to pursue knowledge that has yet to be realised—learning "what is not yet there" (Engeström, 2016). This transformative process progresses through a sequence of epistemic actions, often depicted as an "expansive learning cycle" or spiral (Figure 3.4). Each phase of the cycle mirrors key principles of learning design, offering distinct opportunities for growth and development (Voogt et al., 2015). As Postholm (2015) explains, these iterative cycles of questioning, envisioning, and implementing do not remain isolated events; rather, they inform and propel the evolution of new practices that integrate diverse working methods and learning strategies. For instance, the act of questioning—frequently triggered by dialogue among individuals—can give rise to collaborative envisioning and deliberate attempts to challenge established routines (Engeström, 2001). However, as Engeström (2008) cautions, the idealised sequence of epistemic actions in the expansive learning cycle is rarely observed in practice. Instead, these stages should be viewed as guiding principles for understanding how subjects might expand their horizons and engage with transformative processes, rather than as a rigid, prescriptive framework.

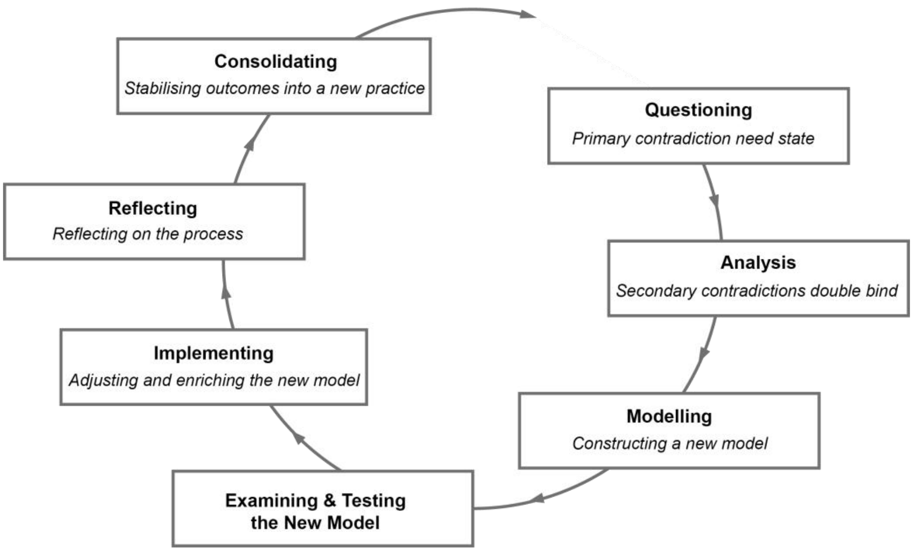

Figure 3.4. Sequence of learning actions in an expansive learning cycle (adapted from Engeström, 2001, 2015).

3.5.3 Application of CHAT in the thesis

Building on the preceding discussion, this study employs CHAT because it affords a holistic perspective on learning activity. The framework enables a multi-angled examination of design work and decision-making, weaving together insights from different traditions and viewpoints (Mwanza & Engeström, 2005). It also makes it possible to analyse what happens when a new "rule" enters the teachers' activity system—specifically, the requirement that they collaborate with designers instead of relying on the solitary practices that once dominated their co-design routines.

While co-design is central to the investigation, the analysis adopts the third generation of CHAT rather than the second. This version of the framework directs attention to the interaction between two activity systems—one organised around teachers, the other around designers—each embedded in its own contextual network. Together, these intertwined systems form the primary unit of analysis. The choice is further supported by research indicating that teacher–designer partnerships now take many forms, from full co-creation to more service-oriented support roles (Richardson et al., 2019). Moreover, existing studies (e.g., Engel & Weber, 2019; Fan et al., 2020; Rong et al., 2025) highlight key differences between these two groups, particularly in their roles and approaches. For example, teachers often lack the design knowledge, skills, or capacity to fully engage in the design process, which contrasts with the skillset of designers who are trained in these areas. Placing teachers and designers within a single activity system would obscure critical distinctions and fail to capture the complexity of their interactions. This is why separating them into distinct activity systems provides richer insights into their roles, collaborations, and challenges.

Figure 3.5 below illustrates how CHAT has been applied in this thesis, representing the two interacting activity systems. The literature reviewed earlier served as the foundation for defining and mapping the components of these systems, offering a structured way to analyse the collaborative dynamics between teachers and designer and uncover potential opportunities for further advancement in the field.

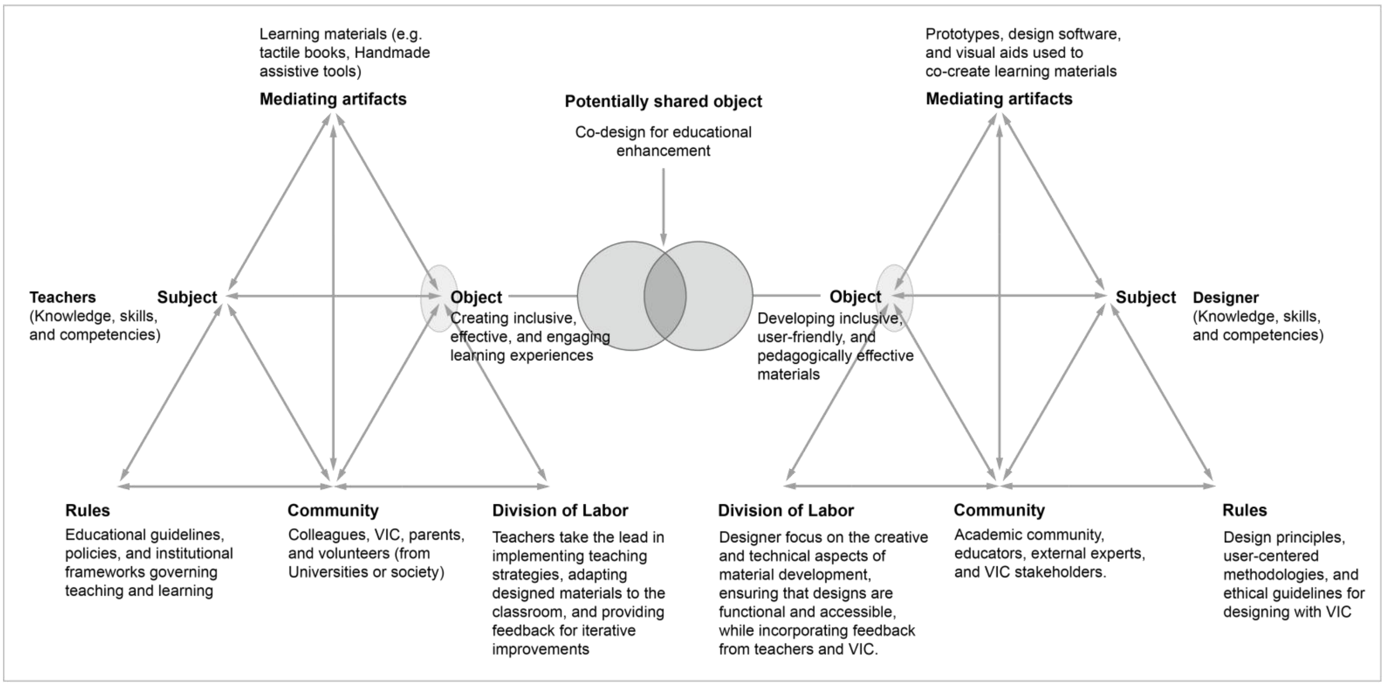

Figure 3.5. Application of CHAT in the present research (adapted from Engeström, 2001).

The ***mediating artifacts*** in CHAT are tools and resources that shape the ways individuals think and act, mediating the relationship between the subject (the actor) and the object (the goal or outcome of the activity) (Engeström, 1999). Understanding the utility, nature, and contributions of these artifacts is essential for grasping how design processes unfold. As shown in Figure 3.5, based on the literature review (sections 2.2.2 and 2.4.1), a range of artifacts play critical roles in the design process. These artifacts include material tools (e.g., tactile graphics, design prototypes, physical teaching materials), psychological tools (e.g., language, cultural signs, and interaction protocols), and research resources from designer's prior work, which can serve as both internal and external representations to guide decisions.

The activity's ***subject*** refers to the individuals or groups involved in the activity, working collaboratively to achieve the shared object (Engeström, 1996). In this study, the subjects are the teachers interacting with designers, as detailed in previous sections. As highlighted in sections 2.2 and 2.4, these subjects bring their individual experiences, knowledge, beliefs about teaching and learning, and attitudes toward design and innovation into the activity. These factors serve as starting points that influence their interactions and their attempts to achieve the activity's object. The role of these components and how they shape the co-design process will be explored in more detail later in the thesis.

The activity's ***object*** is the central motivating force in the co-design process. For this study, the object is to design quality learning materials that are accessible and beneficial for VIC. This object encompasses two main aspects: (1) the development of designerly thinking and the pedagogical rationale underlying inclusive pedagogy to improve educational outcomes (see section 2.2.1), and (2) the quality of the design products created for VIC (see sections 2.3 and 2.4). Consistent with Engeström's (2001) view, the object is treated not as a fixed endpoint but as an evolving target that is continually reshaped by participants' day-to-day actions and the surrounding context—making its ongoing transformation a key focus of inquiry.

Rules play a significant role in guiding or constraining the actions of the subjects. These rules can be explicit, such as formal policies and regulations, or implicit, including norms, values, and cultural expectations that shape behaviour within the system (Engeström, 1999). As reviewed in sections 2.2.2, 2.2.3, and 2.5.2, rules in this study include institutional policies and standards for learning, ethical considerations (e.g., informed consent, safeguarding VIC), and pedagogical norms that influence the interactions among teachers, designers, and VIC. These rules help shape the parameters within which co-design activities take place, impacting the way participants engage with one another and the process itself.

The ***community*** consists of the individuals who share the same activity system and collaborate towards achieving the object. The community's shared norms, values, and practices significantly influence the interactions between the subjects and their goals. Communities of practice, as defined by Wenger (1999), are groups of individuals who share a common concern or interest and continuously learn how to improve their practice through regular interaction. These communities can be informal or formal, with varying levels of participation (e.g., core, active, peripheral). In this study, the community refers to a broader network that includes colleagues within educational institutions, as well as the wider VIC community, which may encompass parents, volunteers, experts, and other stakeholders involved in the co-design process (see sections 2.2 and 2.4).

Division of labour refers to the distribution of tasks and responsibilities within the activity system, based on the roles, expertise, and skills of the subjects and community members in different contexts. While the division of labour may include formal roles, it also reflects the social roles that emerge within the activity, depending on each actor's capabilities. For instance, in the design of accessible learning materials, teachers typically bring pedagogical expertise and content knowledge, while designers contribute specialised design skills for tactile graphics and other accessible resources. However, division of labour is not always a neutral process; it can also give rise to power dynamics. These dynamics stem from the actual or perceived status of different actors (i.e., teachers, designer) and how these roles are viewed within the broader social and institutional context (as discussed in sections 2.2.2, 2.4, and 2.5.2), which deserves further explore in this research.

3.5.4 Polyfunctional use of CHAT

This subsection brings the preceding arguments together and clarifies the many functions CHAT fulfils across the dissertation. From the start, its core concepts guided the study's design, offering a heuristic map for identifying and positioning each element of the activity system and for situating the object within its structural and contextual setting. Because CHAT is well suited to analysing special-education contexts (Bal et al., 2021), it was adopted here to examine work with CwD, helping to question where the principal actors fit within their activity networks and prompting a more rigorous engagement with the literature to justify the project's direction. An early awareness of the study's complexity informed this choice, and that awareness only intensified as the research progressed.

Moreover, CHAT played an instrumental role in the research design and data collection phases. The concept of historicity inspired a multi-stage data collection strategy, aimed at capturing practices over time. Other key CHAT concepts, such as contradictions and multi-voicedness, informed the approach to gathering qualitative data from a range of stakeholders—including teachers, experts, and VIC. Methods such as interviews, workshops, and observations were employed to identify contradictions that emerged during actor exchanges, instances of boundary crossing, and why particular design decisions are more dominant than others. Framing the inquiry with CHAT brought these nuances into sharp relief—facets a more traditional research lens might have glossed over or missed entirely.

In terms of data interpretation, CHAT provided a solid theoretical foundation for meaning-making. By leveraging CHAT's theoretical concepts, the thesis offered nuanced interpretations and plausible explanations of the data. Its focus on situational dynamics and the relationships between the components of activity systems was key in examining the broader, historically and culturally embedded practices that shape the co-design process. For instance, expansive learning—a core principle of CHAT—was utilised to interpret how the subjects navigated contradictions through innovative actions that transformed their practices. This approach revealed how new knowledge emerged from the collaborative process, deepening our understanding of how co-design can serve as a transformative pedagogical tool for both teachers and VIC. Finally, CHAT provided a common language for describing and interpreting the complexities inherent in the data. This shared vocabulary facilitated the articulation of intricate meanings and supported the formulation of generalisable conclusions. The adoption of CHAT thus ensured that the study was grounded in a rigorous theoretical framework that provided a comprehensive understanding of the multifaceted nature of co-design in the educational context.

3.6 Conclusion

This chapter establishes the third generation of CHAT as the foundational theoretical framework for this thesis, emphasising its suitability for analysing the complex, collaborative processes of co-design within educational contexts. By tracing CHAT's evolution from Vygotsky's sociocultural theory to its third generation as developed by Engeström, the chapter has highlighted CHAT's ability to accommodate diverse perspectives, address systemic contradictions, and integrate historical and sociocultural dimensions into the analysis. The polyfunctional role of CHAT throughout the study has been underscored, from shaping the research design to providing tools for interpreting data and framing co-design as a transformative pedagogical process. Crucially, CHAT works alongside the conceptualisations of design and designer identity presented in Sections 2.2 and 2.4, reinforcing the theoretical underpinnings of this research. The next chapter details the methodology and elaborates on how CHAT informed the methodological choices made in this study.

4. Methodology

This chapter outlines the research methodology, describing the overall approach, recruiting strategies, data collection tools and procedures, ethical considerations, and methods for data analysis, while critically addressing issues of trustworthiness.

4.1 Introduction

Mohanty (1988) contends that no research can be wholly neutral, while Clegg et al. (2009, p. 24) emphasise that "every research activity is an exercise in research ethics, every research question is a moral dilemma, and every research decision is an instantiation of values." Within this ethical framework, I held a responsibility to ensure that each methodological choice was guided by careful reflection on how participants were impacted, involved, and represented. This chapter details the methodological choices that steer the study, adopting Crotty's (1998) framework as an organising scaffold. Table 4.1 aligns each element of the design with Crotty's categories for ease of reference. I first discuss the study's philosophical foundations and justify the selected methodological stance. Next, I explain participant recruitment and selection, outline the data-gathering techniques and procedures, and highlight the ethical considerations that guided these activities. The chapter then describes the analytic strategies employed and the steps taken to establish the study's trustworthiness, before concluding with a reflection on the limitations and challenges encountered during the research.

Table 4.1. Overview of the study's epistemological stance, theoretical lens, methodological framework, and specific methods.

Epistemology	Theoretical perspective	Methodology	Methods
Social constructivism	Interpretivism	Qualitative case study	Interviews Observations Documents Prototyping Workshops

4.2 Research paradigm

The research paradigm encompasses the epistemology and theoretical perspective that direct how researchers understand the world (Kuhn, 1962). Often described as a researcher's "worldview" (Mackenzie & Knipe, 2006), it represents a set of shared beliefs guiding the interpretation of research data. As Guba (1990, p. 17) puts it, this philosophical worldview is "a set of beliefs that guide action." Consequently, the research paradigm profoundly influences methodological decisions—shaping the choice of methods, approaches to data analysis, and the rationale behind these choices.

Crotty (1998) proposes a four-level elements that links philosophical assumptions to concrete research practices: epistemology - theoretical perspective - methodology - methods. This structure ensures logical coherence from worldview to technique. **Epistemology** specifies assumptions about how knowledge is formed (e.g., objectivism, constructionism, subjectivism); **theoretical perspective** provides a philosophical stance for interpreting the world (e.g., positivism, interpretivism, critical inquiry, feminism, postmodernism); **methodology** denotes the research strategy consistent with that stance (e.g., ethnography, case study, grounded theory, action research); and **methods** are the techniques used to generate and analyse data (e.g., interviews, observations, or workshops) (Crotty, 1998; Gray, 2014; Robson, 2002). Framing the study through this four-level lens clarifies why particular techniques are appropriate and how they align with the study's philosophical commitments.

Specifically, Crotty (1998) defines epistemology as "providing a philosophical grounding for deciding what kinds of knowledge are possible and how we can ensure that they are both adequate and legitimate." From this perspective, three core epistemological positions are commonly distinguished (Figure 4.1): objectivism, constructivism, and subjectivism. Objectivism posits that objects contain inherent meaning, and researchers aim to discover objective truths without influencing the phenomena under investigation (Crotty, 1998). In contrast, constructivism maintains that meaning is co-created through human interaction with reality, allowing multiple interpretations of the same phenomenon. Subjectivism, meanwhile, holds that meaning is imposed on an object by the individual, rather than emerging from the interplay between subject and object (Crotty, 1998).

Different theoretical perspectives align with these epistemological positions. The most frequently cited include positivism, interpretivism, and critical inquiry, alongside postmodernism and feminism (Gray, 2014). Positivism, typically linked with quantitative research, emphasises scientific observation and objectivity. Interpretivism, often connected with constructivism and qualitative approaches, stresses that social phenomena differ from natural phenomena and therefore require a distinct logic of inquiry. Critical inquiry offers yet another lens, contending that knowledge is shaped by social position and that some groups are systematically privileged over others (Gray, 2014). In adopting a critical inquiry perspective, researchers not only interpret the world but also seek to transform it.

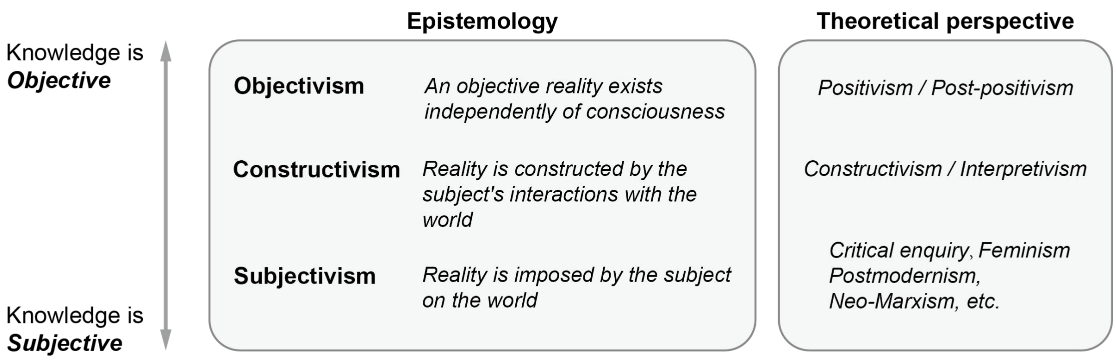

Figure 4.1. Epistemological stances and theoretical perspectives (adapted from Crotty, 1998; Gray, 2014; Robson, 2002).

From an epistemological standpoint, this thesis adopts social constructionism, which holds that meaning is co-created through human interaction and situated practices (Berger & Luckmann, 1966; Crotty, 1998). Rather than presuming inherent meanings in objects, constructionism treats knowledge as relational and historically contingent—emerging as people engage with material and social environments under interpretation. This position directly supports inquiries where multiple stakeholders negotiate meanings in context and where materials and tools mediate learning and action.

Aligned with constructionism, the study takes an interpretivist theoretical perspective that treats social reality as culturally and historically situated and, therefore, multiply interpretable (Crotty, 1998; Cohen et al., 2011). I further adopt a hermeneutic orientation, recognising that understanding unfolds through an iterative "part-whole" movement of interpretation (Gadamer, 1979). In practice, participants' utterances, actions, and artefacts are read against the evolving whole of the activity; researcher and participants co-interpret meanings over time. This stance resonates with the principles of CHAT (more details in section 3.5), which foregrounds mediated, collective activity and the interdependence of subjects, objects, rules, tools, and community (Roth & Lee, 2007). CHAT provides a mid-range theoretical lens for articulating how meanings and learning are negotiated through socio-material arrangements rather than residing solely in individuals.

Methodologically, these commitments justify a qualitative, interpretive design combining case study with co-design elements appropriate to the educational settings under study. Such a strategy privileges depth, context, and process—critical for tracing how VIC, teachers, designer, and materials co-produce meaning in learning activities. Consistent with this methodology, the study employs semi-structured interviews, participant observation, and co-design workshops, supplemented by artefact/document analysis. These flexible and evolving methods support rapport-building and the recovery of lived meanings (Chilisa & Kawulich, 2012; Creswell, 2013), while CHAT informed mapping helps connect micro-interactions to the organisation of collective activity.

Analytically, the interpretivist hermeneutic stance implies caution in claims: findings are presented as contextual, historically situated interpretations, not universal truths (Crotty, 1998; Guba & Lincoln, 1994). Rigour is pursued through triangulation across methods, iterative memoing and reflexive notes, thick description of process and materials, and member oriented sense checking where appropriate. Notably, under an interpretivist paradigm, the researcher is neither detached nor neutral; their inquiries and values inevitably influence the meanings produced (Merriam, 1998). Consequently, this thesis aims to capture and represent participants' constructions of their social realities—formed through dialogic processes during data collection—while acknowledging my role as the principal interpreter of these insights (Merriam, 1998). Accordingly, I make explicit my interpretive role and positionality (please see details in section 4.4), while foregrounding participants' constructions as they emerged dialogically during the research process.

4.3 Research Methodology

This study sought to examine how teachers and designers collaborate to make design choices for VIC. Specifically, it aimed to understand the practices and experiences of key stakeholders engaged in a co-design process. Given the need to understand how participants interpret their experiences, construct their realities, and ascribe meaning to those experiences, a qualitative research strategy was the most appropriate choice (Merriam & Tisdell, 2015).

Some of the traditional research strategies have been reviewed for this PhD project (Table 4.2). The case study method was adopted to gain a detailed, in-depth understanding of a complex phenomenon in a particular context—collecting multiple data sources to address "why" and "how" questions (Stake et al., 2000). In this thesis context, these questions included how the design process unfolded, why certain design decisions were made, and the underlying perceptions of individuals and groups involved. A key consideration in case study research involves establishing the boundaries of the case. Merriam (1998) underscores that the object is the essence of a definition of case studies, meaning that the case is an entity—a unit that can be clearly delineated—whether it is a single individual or a broader social system (e.g., a school system). In this study, CHAT guided the identification of the unit of analysis and thus provided clear boundaries for the case. Meanwhile, Yin (2018, p. 16) defines case study as “an all-encompassing mode of inquiry with its own logic of design,” highlighting the importance of drawing on multiple sources of information to capture the case in its natural setting (Yin, 1984). Consequently, one vital aspect of case study research is *triangulation*—a process involving the integration of diverse data sources—which will be discussed in Section 4.8.

Table 4.2. Traditional research strategies (adapted from Gray, 2014;Robson, 2002; Yin, 1984).

Case study	To develop detailed, intensive knowledge about a single case or a number of related cases. It involves an empirical inquiry that investigates a contemporary phenomenon within its real-life context using multiple sources of evidence
Ethnography	To capture, interpret, and explain how a group, organisation, or community lives, experiences, and makes sense of their environment. It explores the nature of social phenomena by making reports of events, often using participant observation
Grounded Theory	To generate theory from data collected during the study. This approach is particularly useful in areas where there is a lack of established theory. It uses a systematic and inductive approach to develop theory grounded in empirical data
Action Research	To investigate complex, real-life problems through iterative and reflective processes. This approach involves close collaboration between researchers and practitioners and is typically carried out through participatory processes

Qualitative case studies are frequently employed to identify and describe phenomena and to contribute to theory development (Kenny & Grotelueschen, 1984). While they have historically been used to generate hypotheses for subsequent quantitative research, they are now often applied to probe more deeply into findings from quantitative studies (Ghesquière et al., 2004). In the context of this study, a qualitative case study approach effectively accommodates the exploratory and interpretive nature of the inquiry, allowing for an iterative process of data collection and analysis. This flexibility is essential for capturing the complexity of co-design processes and for adapting the investigation in response to emerging findings. Therefore, it supports a nuanced understanding of how co-design can function as a transformative pedagogical tool.

4.4 The Researcher's Positioning

> "The positionality that researchers bring to their work, and the personal experiences through which positionality is shaped, may influence what researchers may bring to research encounters, their choice of processes, and their interpretation of outcomes" (Foote & Bartell, 2011, p.46).

This statement highlights how a researcher's positionality can shape every aspect of the research process. Positionality encompasses both culturally ascribed or fixed attributes—such as gender, race, and nationality—and subjective or contextual dimensions, including personal life history and experiences (Chiseri-Strater, 1996). I understand my positionality as intersectional and situated: nationality (Chinese), professional formation (designer trained in Australia/US/UK), linguistic repertoire (Mandarin/English), caregiver identity, and institutional affiliations together afforded particular ways of seeing and acting in the field. Therefore, I treat positionality here not as a one-off disclosure but as an ongoing analytic and ethical commitment shaping relationships, design moves, and interpretation. In my case, being from the same country as my participants, China, provides notable advantages. Under a social constructionist epistemology, researchers are often expected to be an "insider" to enrich the subjective dimension of the research (Griffith, 1998). Shared cultural background offers a lived familiarity with the group under study, contributing a *tacit knowledge* unavailable to an "outsider," or someone without close cultural ties (Griffith, 1998). Moreover, this familiarity can foster trust and rapport with participants, as shared language and cultural cues reduce communication barriers.

These positions were consequential in three phases. (1) Access and case selection. Recruiting a site required mobilising parent networks, extended WeChat calls, and face-to-face negotiation with the regional director of Bethel China. My cultural and linguistic insider status facilitated rapport, while my university affiliation and designer identity positioned me as a potential resource to the institution. (2) Fieldwork and role navigation. I adopted a dual role as designer and researcher.As a designer, I offered proactive (e.g., workshop guidance) and reactive (just-in-time) support; as a researcher, I minimised intervention during interviews/observations to preserve data integrity. Maintaining this boundary was not always straightforward: being perceived as a designer sometimes amplified my voice relative to teachers and children. I responded by using “launching questions” (Jaber & Hammer, 2016, p. 199) to redistribute authorship, surfacing children’s and teachers’ ideas before offering my own, and by documenting decision points that might reflect my influence. (3) Interpretation and representation. My transnational training exposed me to inclusion ecosystems that normalise standards, libraries, and production workflows. This risks over-valuing transferability and under-valuing situated improvisation. To mitigate this, interpretations were triangulated across stakeholders (teachers, experts, children) and time, and anchored in thick description of the material ecologies of practice. I also used supervisory debriefs, peer reviews, external presentations, and an audit trail to check for import bias. Rather than seeking neutrality, I made my reasoning public and revisable, treating reflexivity as part of the evidence chain. This responds to contemporary calls to foreground how educator/researcher worldviews and experiences shape pedagogical encounters and their power dynamics (Suhendra & St John, 2025).

4.5 The Research Participants

This section outlines the reasoning that underpinned my selection of institution, experts and VIC for the research. The number of participants in each data collection phase is reflected in Table 4.3.

Table 4.3. Number of teachers, experts and VIC that participated in the research.

	Interviews	Observations	Prototyping	Workshop 1	Workshop 2
Teachers	8	8	4	2	1
Experts	3	-	-	-	-
VIC	5	21	21	12	10

4.5.1 Selection of institution

During the first half of 2023, I explored potential collaborations with various schools and institutions in China through emails, phone calls, and social media platforms (e.g., Rednote). However, none of the special schools were willing to support an individual research project without an official collaboration agreement between my university and their institution. Consequently, I turned to parents of VIC across the country via the Rednote platform, seeking introductions to private, unofficial institutions. During this search, I used WeChat calls to discuss each institution's services and teaching methods with parents, thereby identifying the most suitable site for this project. In June 2023, I traveled to China to meet with the regional director of Bethel China (Beijing) and discuss the practical details of the study. All eight teachers (Table 4.4) at this institution participated, leading me to select Bethel China as the case for the following reasons:

- *Experience Working with Researchers*

Established in 2003, Bethel China is a nonprofit institution specialising in early intervention, education, and vocational training for disadvantaged children who are blind or visually impaired. Dedicated to enabling these children to live fulfilling, independent lives, Bethel draws on the research and data generated through its Love is Blind project to disseminate academic and medical resources nationwide. This background demonstrates Bethel China's proven capacity to partner with external researchers.

- Diverse Population of VIC in Beijing

Bethel China operates six centres (Beijing, Zhengzhou, Jiaozuo, Nanjing, Jingdezhen, and Shangrao), which collectively provide care, specialised education, vocational training, and medical services for approximately 130 VIC—many of whom are orphans. The Beijing centre, in particular, serves children from various regions of China. Additionally, the presence of key service providers, such as the China Braille Library and Beijing Tongren Hospital (widely regarded as the nation's leading eye hospital), makes Beijing a uniquely rich environment for research on visual impairment.

Table 4.4. Basic information of the teachers.

Teacher	Code	Gender	Age	Experience in VIC teaching
Ms. Chen	T1	Female	39	4 months
Ms. Fang	T2	Female	41	15 years
Ms. Geng	T3	Female	48	20 years
Ms. Guo	T4	Female	36	5 years
Ms. Zhang	T5	Female	42	11 years
Ms. Huang	T6	Female	46	15 years
Ms. Zhao	T7	Female	31	1 year
Ms. Qu	T8	Female	38	17 years

4.5.2 Selections of experts

As noted in Section 1.1, research on visual impairment in China is limited, and even fewer researchers possess a background or experience in design. To locate relevant expertise, I reached out to individuals working on design for VIC by using the contact details of corresponding authors from published papers. As a result, one professor (E2) and an Editor-in-Chief from a Chine Braille Press (E1) responded and agreed to be interviewed, while another expert (E3) agreed to participate through the professor's referral.

4.5.3 Selections of children

All 21 VIC at the Beijing Centre participated in the project. However, given the challenges of interviewing them (discussed in detail in Section 4.6.1), only 5 were ultimately selected for formal interviews, following two months of observation and communication. Teachers at the institution facilitated participant recruitment for both workshops, and all selected children displayed typical cognitive development. Because the institution has long supported families of VIC and earned their trust, it played a pivotal role in organising the workshops and identifying participants. Table 4.5 provides the children's basic information. Each child was assigned a code to protect privacy; the note indicates any children who experience significant communication challenges or have multiple impairments.

Table 4.5. Basic information on VIC at different stages of data collection.

	Code	Gender	Age	Sight	Note
Interviews	A	Female	9	Blindness	
	B	Female	6	Blindness	
	C	Female	8	Blindness	
	D	Male	7	Blindness	Craniopharyngioma
	E	Male	6	Less than 0.1	
Observations/ Prototyping	C1	Female	5	Blindness	Multiple disabilities
	C2	Male	4	Blindness	Multiple disabilities
	C3	Female	5	Blindness	
	C4	Male	6	Blindness	
	C5	Female	9	Blindness	
	C6	Female	6	Blindness	
	C7	Female	8	Blindness	
	C8	Male	7	Blindness	Craniopharyngioma
	C9	Male	6	Blindness	
	C10	Female	4	Blindness	Multiple disabilities
	C11	Female	6	Blindness	
	C12	Female	7	Blindness	
	C13	Male	10	Blindness	Uncommunicative
	C14	Female	6	Blindness	Multiple disabilities
	C15	Male	5	Blindness	
	C16	Female	4	Blindness	Uncommunicative
	C17	Male	4	Blindness	Multiple disabilities
	C18	Male	5	Blindness	Multiple disabilities
	C19	Male	6	Blindness	Multiple disabilities
	C20	Female	7	Blindness	Multiple disabilities
	C21	Female	6	Blindness	
Workshop 1	C1	Male	9	Blindness	
	C2	Male	8	Blindness	
	C3	Male	10	Blindness	

	C4	Female	7	Blindness	
	C5	Female	7	Blindness	
	C6	Male	10	Blindness	Uncommunicative
	C7	Female	11	Blindness	
	C8	Female	12	Blindness	
	C9	Female	11	Blindness	
	C10	Male	9	Blindness	
	C11	Male	6	Less than 0.1	
	C12	Male	7	Blindness	
Workshop 2	C1	Female	12	Blindness	Medulloblastoma
	C2	Male	4	Left eye has light perception	Craniopharyngioma
	C3	Female	7	Both eyes have light perception	
	C4	Male	4	Blindness	Craniopharyngioma
	C5	Male	5	Left eye 0.02	
	C6	Male	6	Right eye 0.03	Craniopharyngioma
	C7	Male	6	Right eye 0.01	Craniopharyngioma
	C8	Female	11	Blindness	
	C9	Female	12	Blindness	
	C10	Male	5	Blindness	Craniopharyngioma

4.6 Data Collection

Formal data collection, following ethical approval, occurred between June 2023 and February 2024. In light of this study's objectives, the chosen methods—encompassing interviews, observations, and analyses of participant behaviours, experiences, and perspectives—were attuned to the subtleties of underlying meaning (Merriam & Tisdell, 2015). Consequently, a multi-staged, multi-method approach was deemed necessary to investigate participants' experiences in designing for and with VIC across an extended timeframe. More importantly, data collection methods and processes are constantly being adapted over time and to specific issues, as many situations are not anticipated before data collection begins. This flexibility is informed by CHAT, which emphasises capturing the historicity of an activity by observing it in motion and in evolution (Sannino & Engeström, 2018). Table 4.6 summarises the data types and sources that are outlined in the next sections.

Table 4.6. Overview of data collection methods and sources.

Methods	**Sources**	**Aims**
Interviews	Semi-structured interviews	To gather in-depth qualitative insights from key stakeholders (teachers, VIC, and experts) regarding their experiences, perceptions, and needs related to the design and use of learning materials and in educational settings
Observations	Photographs Field notes Video recording	To observe the interactions between VIC, teachers, and materials in real-time educational contexts. Observations aim to identify patterns in engagement, challenges faced during learning, and the effectiveness of different materials and activities, providing contextual data that supports the findings from interviews and literature reviews.
Documents	Learning materials Teaching documents Design documents	To analyse existing curriculum documents, learning materials, and other educational resources. The aim is to evaluate the alignment of these documents with the needs and preferences of visually impaired children, and to identify potential gaps or areas for improvement in the design of educational materials and practices.
Prototyping	Iterative prototyping Field notes Photographs	To develop and test prototype educational materials and tactile graphics in collaboration with VIC and teachers. The prototyping process aims to iteratively refine designs based on feedback, ensuring that the final products are accessible, effective, and engaging for all participants. The goal is to enhance the learning experience and better understand the role of materiality in education for VIC.
Workshops	Video recording Photographs Semi-structured interviews	To facilitate co-design workshops where VIC, teachers, and designers collaboratively create and evaluate learning tools and activities. The aim is to foster a co-design process that empowers all participants, explores different perspectives, and results in more inclusive, meaningful educational resources.

4.6.1 Interviews

Punch (2005, p.144) asserts that “interview is the most prominent data collection tool in qualitative research." Interviews are seen as "the main road to multiple realities" (Stake, 1995, p.64), as they enable participants to articulate and reflect on their feelings, experiences, and evaluations of their practices (Savin-Baden & Major, 2013). The interview method was selected for this study due to its inherent flexibility, which allows the researcher to explore participants' perspectives on issues or concerns that are central to the research. This is particularly valuable, as interviews provide participants the opportunity to voice their own thoughts and feelings on topics of interest (Berg, 2004).

lshenqeeti (2014) notes that interviews are particularly effective when the researcher seeks to provide a nuanced account of participants or events within their natural contexts. When the research context is a critical variable, as it is in the present study, interviews become an essential tool for understanding how this context influences participants' roles, practices, and outcomes. As previously discussed, the context of China is pivotal to this study, making interviews an ideal method for capturing how the local environment impacts participants' experiences and achievements. Kvale (1996) further argues that interviews are particularly valuable when the topics under investigation are not easily observable. This observation is directly relevant to the current study, as topics such as teaching and learning—shaped by cultural background and personal beliefs—cannot be fully understood or analysed without providing participants the opportunity to express their perspectives.

While focus groups or group interviews may initially appear to be a promising choice for exploring collaborative design practices, one-on-one interviews were deemed more appropriate for this study. This decision was influenced by the complex dynamics between teachers and experts, who occupy different roles within the research context. For instance, hierarchical power imbalances might inhibit participants from expressing themselves fully if a more senior member is present (Kitzinger, 1995). To ensure that each participant felt comfortable sharing their experiences and insights, a one-on-one interview format was chosen, thus maximising the depth of the data collected. Moreover, given that participants belong to distinct activity systems, it was felt that individual interviews would allow each person to present their views without influence from others.

Unexpectedly, however, the initial one-on-one interviews with VIC did not yield the desired outcomes. As a result, the interviews with VIC were later shifted to a group interview, a change that will be discussed in more detail in the subsequent section.

Finally, a semi-structured interview format was preferred over more rigidly structured or unstructured designs. This approach offers the advantage of a consistent set of open-ended questions, ensuring comparability across cases (Cohen et al., 2011), while still permitting the flexibility to explore emergent ideas based on participants' responses (Bryman, 2016). Semi-structured interview guides for teachers and other stakeholders focused on: professional background and teaching area; approaches to learning about children's needs; strategies for deepening understanding of emotions/experiences; recurrent classroom challenges; and illustrative episodes from practice. These guides are reproduced in Appendix D, which also contains the exact question wordings used in the study.

Interviews with teachers

Kvale and Brinkmann (2015) assert that the quality of a study is contingent upon both the researcher's craftsmanship and the rigor of the research process. In this regard, the validity and reliability of the study are bolstered by its design, particularly through the involvement of researcher, and, to some extent, the participants themselves in the data collection and analysis process. Furthermore, I contend that the validity of the interview findings is strengthened by my prior familiarity with the institution, teachers, and VIC, having spent an extended period collecting observational data before conducting the interviews. This pre-existing rapport allowed shared experiences to underpin much of the dialogue between myself and the participants. As a result, this interaction ensured that my interviews aligned as closely as possible with the participants' own perceptions of their roles and actions (Miles & Huberman, 1994). Additionally, my flexibility in adjusting interview schedules to accommodate teachers' availability ensured that they had ample opportunity to express their ideas. This arrangement provided considerable room for teachers to introduce ideas independently and to reflect on their practices in a way that best suited their perspectives.

The interviews were structured around semi-structured, open-ended questions intended to draw out rich accounts of the rationales, challenges, and assumptions informing teachers' pedagogical design choices (see Appendix D). Questions probed the design workflow, instructional strategies, contextual influences on decision-making, and insights participants hoped to apply in future practice. The structure of the questions was informed by the study's objectives and anchored in the relevant literature. To ensure the questions were fit for purpose, I piloted them with teachers. This pilot phase proved valuable, as it confirmed that most of the semi-structured, open-ended questions generated insightful responses. Some modifications were made, such as altering the sequence of certain questions to improve the flow of the interview. Additionally, a few questions were rephrased for greater clarity and specificity, as initial feedback suggested that they were somewhat abstract and difficult for teachers to engage with.

Interviews with experts

The interviews with the experts were conducted one-on-one, using open-ended questions. Prior to the interviews, I thoroughly reviewed each expert's published work and tailored the questions to align with their specific research areas and interests (see Appendix D). The questions began with broader, less contentious issues and gradually progressed to more sensitive topics, including policy matters and perceptions regarding the development of design products for VIC.

Interviews with VIC

Interviews with VIC proved significantly more challenging and complex than anticipated, often diverging from the expectations set in the existing literature. Despite having established a positive rapport with the children, my initial attempts at conducting one-on-one interviews were largely unsuccessful, with only one child providing thoughtful responses to all questions. While the literature often advocates for focus groups or group interviews as suitable methods for young children—including those as young as four or five years—and for individuals with disabilities such as visual or communication impairments (Decarlo et al., 2012; Larsson & Lamb, 2009; Markham et al., 2009), practical difficulties made such approaches difficult to implement. Teachers at the institution found it challenging to coordinate a group of children to sit together and engage with questions based on their experiences. Consequently, I continued experimenting with one-on-one interviews, attempting to conduct them when the children appeared to be in a receptive state. However, this approach did not yield the desired results, even when I adapted the method to asking just one question per day.

After consulting with the teachers, I eventually shifted to group interviews. Although these sessions were often chaotic—children frequently left their seats, and teachers had to encourage participation with snacks—I was able to complete a half-hour group interview with substantial assistance from the teacher. I recorded the whole interview on video. Drawing on Reich's (2000) recommendations, I adopted an animated tone of voice, modulated based on each child's responses, and allowed for frequent breaks and access to small toys to keep the children engaged. Ideally, interviews with younger VIC should resemble storytime, providing a comfortable and familiar context for communication.

Recognising the difficulties encountered in the early stages of the study, interviews conducted during the workshop were intentionally brief, averaging just five minutes per child, to better accommodate the unique needs of VIC. Previous research indicates that complex or opinion-based questions are particularly challenging for these children to answer, and their ability to maintain concentration over extended periods is limited (Bushin, 2007; Christensen & James, 2000; Einarsdottir, 2007). Even seemingly simple questions, such as “Can you describe a dragon?” often led to hesitation or an inability to articulate a clear response, likely due to the cognitive demand of visualising abstract concepts. To address these challenges, the interview strategy was adjusted to include indirect and approachable questions such as “What was fun about this workshop?” or “Did you find anything difficult?” These questions were designed to elicit the children’s thoughts in a manner that aligned more closely with their communication abilities and comfort levels (see Appendix D). This adaptive approach not only facilitated more meaningful engagement but also highlighted the importance of tailoring research methods to the specific needs and capabilities of VIC.

4.6.2 Observations

Case studies occur within real-world settings, making observation a valuable method for collecting data from naturally occurring social phenomena (Cohen et al., 2011; Yin, 2018). Through observation, researchers can capture unique aspects, such as finer-grained details about design foci and interaction patterns among participants, that are not as readily accessible through interviews or document analysis. Consequently, combining observational data with interview findings allows for a dual perspective: *zooming in* (through observations) to examine specific interactions and *zooming out* (through interviews) to contextualise these interactions within broader narratives (Goodyear, 2020).

In this study, the observation procedure involved shadowing daily lessons to understand how teachers instruct VIC and the design decisions they make in practice. The observations were designed to be non-intrusive, avoiding interruptions or questioning that might disrupt the natural flow of the classroom or influence participants' behaviours and thought processes. However, it is acknowledged that the presence of an external researcher is inevitably noticed by those being observed, potentially affecting their behaviour. To minimise this impact and preserve the naturalness of the setting, I made efforts to "fade into the background" and become a negligible presence (Denscombe, 2007). Over time, as the observations extended over a month, teachers and children became accustomed to my presence, reducing any potential disruption to an almost negligible level.

An observation protocol was created to steer field-note taking, spotlighting several core areas: the organisational and human context (e.g., participants present and the project's design stage), the design workflow itself, interaction patterns that either enabled or constrained decisions, the reasoning behind design choices, and participants' commitments to inclusive pedagogy (see Appendix E). Grounded in CHAT, the guide highlighted analytically significant cues—such as contradictions with previous activity, emerging tensions, and negotiation moments among collaborators. While the protocol lent structure, it remained deliberately flexible, allowing the capture of unanticipated, context-specific details in keeping with the study's exploratory goal of portraying authentic behaviours and practices rather than testing predefined hypotheses. Finally, the observations were conducted over a 28-week period, during which more than 1,000 photos and short videos were collected.

4.6.3 Documents

In this research, documents that offered relevant insights into the research aims were collected and analysed (see Table 4.6). These documents served as secondary sources of evidence, complementing and corroborating data derived from interviews and observations (Yin, 2018). As Savin-Baden and Major (2013) contend, documents represent tangible artifacts of social meaning-making that can illuminate cultural and historical norms, team visions, and collective actions. Consequently, their inclusion in qualitative inquiry adds both depth and breadth to the analysis. In cases where documentary evidence contradicted findings from other data sources, the discrepancies were treated as valuable cues for further investigation. For instance, participants could be asked to provide additional explanations or perspectives regarding points of divergence reflected in the documents. To ensure a critical and nuanced interpretation of these materials, this research adopted Yin's (2018) recommended strategy of examining the specific purpose and intended audience of each document. This approach facilitated a more rigorous and context-sensitive analysis, enabling a deeper understanding of the documents' implications within the broader research framework.

4.6.4 Prototyping

Wensveen and Matthews (2015) contend that prototyping can function as a vital means of inquiry within research processes that inherently involve design. They draw attention to prototyping in the context of what they term "constructive design research," defined as "research that imagines and builds new things and describes and explains these constructions." This perspective aligns with Penuel et al. (2007, p. 53), who describe a process in which "teachers, researchers, and developers work together in defined roles to design an educational innovation, realise the design in one or more prototypes, and evaluate each prototype's significance for addressing a concrete educational need." In this study, prototypes are deployed as a "means of inquiry" (Wensveen & Matthews, 2015, p. 267), in much the way that "scientists use specifically designed instruments to collect, record and measure phenomena." Research that treats design as an intervention—examining its consequences or deploying prototypes in the field (e.g., Matthews et al., 2008) to contribute to design scholarship—similarly uses prototypes to create a context that sheds light on design-relevant concerns.

For researchers and designers alike, prototypes constitute significant cognitive tools (Eladhari & Ollila, 2012). Although the term “prototype” carries various connotations, here it refers to any artifact that can be interacted with to demonstrate how a system operates. Such artifacts are often disposable (Agustin et al., 2007). In this study, prototyping marked my initial collaboration with teachers and VIC after conducting interviews and observations, with the aim of verifying that our design decisions genuinely enhance VIC’s learning experiences.

The traditional waterfall model (Royce, 1987) envisions design, implementation, and evaluation as distinct phases proceeding in linear succession. By contrast, iterative design processes for learning materials (e.g., Moonen, 1999; Shih et al., 2008; Syafril et al., 2021) advocate multiple cycles of design, testing, and development. Critics argue that even these models may not be iterative enough (Fallman, 2003), suggesting that design, implementation, and evaluation should be tightly interwoven. My own experience indicates that producing research prototypes is most successful when designer, teachers, and VIC collaborate closely, refining the materials during or between individual test sessions. Such collaborative approaches have been effectively employed by others as well (Martin, 2000; Medlock et al., 2002). Figure 4.2 illustrates a prototyping cycle.

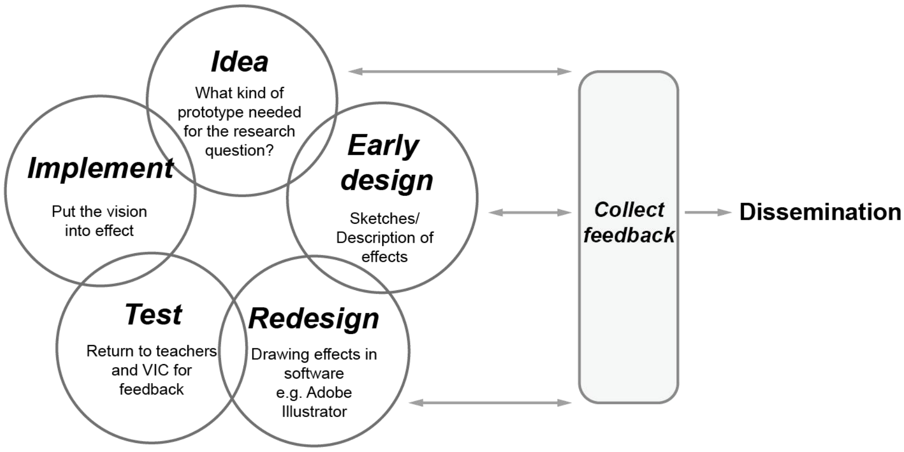

Figure 4.2. A prototyping process cycle.

4.6.5 Workshops

The co-design workshops drew inspiration from the work of Könings et al. (2005; 2014), whose findings reveal that involving designers, teachers, and students can enhance alignment among stakeholders' needs and foster more effective learning environments. CHAT provided the conceptual foundation for this endeavour, recognising co-design as a complex, dynamic activity system encompassing subjects (people), objects, tools (materials), rules, community, and divisions of labour. Additionally, the workshops were influenced by the view of design as "a communicative process among individuals that enables collective actions" (Jenlink, 2001, p. 350). Within the scope of this study, I conducted two workshops, the essential details of which appear in Table 4.7.

Table 4.7. Overview of the workshops .

Workshop	**1**	**2**
Date	20 Oct, 2023	31 Oct, 2023
Duration of workshop	2 hours	3 hours
Number of participants	12 VIC, 2 teachers, 1 designer, 12 parents, 2 volunteers	10 VIC, 1 teachers, 1 designer, 10 parents
Location	Charity Coffee Shop	Bethel China
Theme	The calendar design for the Year of the Dragon	The Underwater World

Workshop 1

An overview of the activities in Workshop 1 appears in Table 4.8, and the full workshop process is detailed in Appendix F. In this session, VIC from diverse regions of China—encompassing varied socio-economic and cultural backgrounds—participated in a co-design endeavour to create a calendar for the Year of the Dragon (2024). The choice of a dragon theme was deliberate, given the dragon's profound cultural significance in Chinese tradition. By focusing on this motif, participants were introduced to the concept of the dragon while simultaneously refining their spatial and sensory awareness and exercising creative agency through tactile materials. The co-design process was central to the study, involving collaboration among VIC, teachers, and designers at every stage. Ultimately, the calendars produced through this co-design workshop were sold for charitable purposes, benefiting the VIC. This participatory approach enabled them to actively shape the final product while learning about cultural traditions in a way that suited their unique sensory needs.

Table 4.8. Workshop 1 outline.

Minutes	Activity	Who	Materials
10	Welcome and Introduction	Teachers	Audio materials
20	Icebreaker Activity	Teachers, VIC	Audio, tactile materials
10	Brainstorming Session	Teachers, VIC, Designer	Tactile materials
40	Hands-on Co-Design Activity	Teachers, VIC, Designer	Tactile materials and art supplies, tactile prototype
20	Sharing and Feedback	Teachers, VIC, Designer	Audio materials
10	Closing Reflection	Teachers, VIC	Audio materials
10	Wrap-up and Goodbyes	Teachers, VIC, Parents	Audio materials

Workshop 2

Findings from Workshop 1 suggested that allocating more time, providing clearer instructions, and incorporating additional practical examples would enhance the workshop experience (see Appendix F). In response, the teacher and I collected further background information about the participating VIC (see Appendix G for the parent-completed forms) and subsequently designed the theme "Underwater World" to align with the children's abilities and contexts. Through this workshop (Table 4.9), our objectives were to (1) foster exploration and understanding of diverse textures and materials, (2) encourage creativity and self-expression by allowing children to craft unique representations of the underwater environment, and (3) deepen their knowledge of marine life and ecosystems through a co-design activity.

Table 4.9. Workshop 2 outline.

Minutes	Activity	Who	Materials
10	Welcome and Introduction	Teachers	Audio materials
15	Icebreaker Activity	Teachers, VIC	Audio, tactile materials
15	Brainstorming Session	Teachers, VIC, Designer	Tactile materials, tactile prototype
90	Hands-on Co-Design Activity	Teachers, VIC, Designer	Tactile materials and art supplies, tactile prototype
25	Sharing and Feedback	Teachers, VIC, Designer	Audio materials, final prototypes
15	Closing Reflection	Teachers, VIC	Audio materials
10	Wrap-up and Goodbyes	Teachers, VIC, Parents	Audio materials

4.7 Data Analysis

This section presents and justifies the data analysis strategies employed in this research. The data from this research was diverse and consisted of a mix of transcribed interviews, videos, photos, and narratives. Consequently, different analysis techniques were also selected to fit the type of data collected. A summary of the techniques is presented in Table 4.10.

Table 4.10. Summary of data collection techniques in relationship with type of data.

Type of data	Reporting of Results	Data analysis technique	Output of the analysis
Transcriptions from interviews	Chapter 5 , 6 and 8	Thematic analysis	Identification of key themes and patterns in participants' experiences and perspectives
Field notes	Chapter 5, 6 and 7	Thematic analysis	Detailed descriptions of observed interactions and design processes

Video recordings	Chapter 5, 7 and 8	Video analysis Content analysis	Identification of significant events and interactions; Analysis of verbal and non-verbal communication, material use, and collaboration
Photographs	Chapter 6, 7 and 8	Content analysis	Visual documentation of design processes, material use, and participant interactions
Documents	Chapter 6	Content analysis	Analysis of curriculum, teaching, and design documents to identify gaps and improvements
Prototypes	Chapter 7 and 8	Content analysis	Evaluation of prototype iterations and their impact on VIC's learning experiences

4.7.1 Thematic Analysis

Thematic analysis served as the primary method for identifying, analysing, and reporting patterns within the data (Braun & Clarke, 2006). This approach effectively organises and describes data in detail while preserving its inherent complexity. Selected for its versatility, thematic analysis also facilitates the synthesis of diverse participant perspectives drawn from multiple sources (Braun & Clarke, 2006).

Braun and Clarke (2019) identify three main strands of thematic analysis: coding reliability, codebook approaches and reflexive thematic analysis. The first two were deemed less suitable for this study because they rely on structured coding frameworks —either fixed categories (codebook approaches) or multiple coders to ensure "accuracy" (coding reliability) (Braun & Clarke, 2019). Such frameworks are incompatible with the interpretive paradigm adopted here, where the researcher and participants jointly construct and interpret multiple realities. Accordingly, reflexive thematic analysis was employed, characterised by a fluid, iterative analytic process in which the researcher engages in prolonged, reflective engagement with the data (Braun & Clarke, 2020). This reflexive approach recognises that no two researchers will produce identical outputs, and thus descriptions, narratives, and discussion points are not mere reflections of an objective reality, simply mirroring "what is there"

(Crotty, 1998).

Regarding coding, there is a choice between deductive and inductive strategies (Braun & Clarke, 2006). Deductive coding is guided by established theory or existing research and involves a predetermined conceptual framework, whereas inductive coding, also known as “bottom-up,” is grounded in the data itself (Clarke & Braun, 2017). As noted in Chapter 3, studies employing CHAT often rely on predefined categories based on its core components (Bligh & Flood, 2017). However, such an approach would have limited this study to specific dimensions, potentially overlooking broader patterns in the data. Conversely, ignoring CHAT and relevant conceptual insights through a strictly inductive approach was equally unsuitable. Thus, I adopted a hybrid strategy, predominantly inductive in the early stages, but incorporating a degree of deductive coding later, drawing on CHAT’s conceptualisations and pertinent literature (Fereday & Muir-Cochrane, 2006; Proudfoot, 2023). This integrated approach facilitated a balanced, context-sensitive interpretation of the data while drawing on established theoretical constructs. The thematic analysis followed Braun and Clarke’s (2006) six-phase phases, outlined in Figure 4.3.

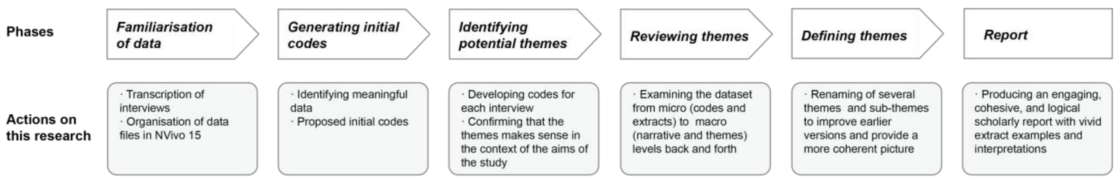

Figure 4.3. Thematic analysis process followed in this research.

4.7.2 Content Analysis

Content analysis is a method of drawing inferences from data by “systematically and objectively identifying special characteristics and categories analysis” (Gray, 2014, pp 691). While it often serves to generate concepts and categories that inform the development of learning materials, content analysis is equally well-suited to investigating deeper meanings, intentions, and consequences (Elo & Kyngäs, 2008). Content analysis can accommodate both quantitative and qualitative data and can be conducted following an inductive and deductive approach (Elo & Kyngäs, 2008). As mentioned before, inductive process is recommended when there is limited existing knowledge on the subject, whereas a deductive process is preferable for studies aiming to test theoretical propositions. Although this research was largely exploratory, it also sought to validate certain emerging insights. Consequently, a hybrid approach that combined inductive and deductive methods was adopted, following the recommendations of Elo and Kyngäs (2008). The overarching content analysis process is illustrated in Figure 4.4.

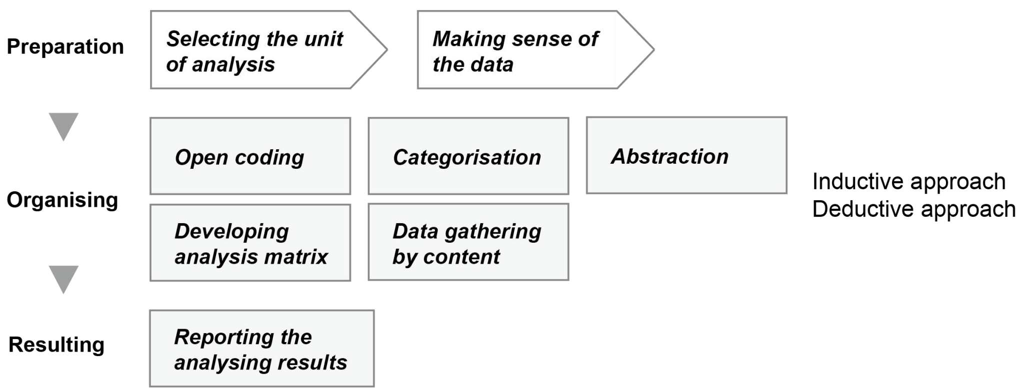

Figure 4.4. Content analysis process followed in this research (adapted from Elo & Kyngäs, 2008).

The coding procedure itself was iterative and unfolded in multiple stages to ensure both thoroughness and rigour. The first phase—open coding—involved breaking the data into discrete units of meaning, guided by the research questions and the CHAT framework. Codes were assigned to segments of text, images, and video reflecting salient concepts, actions, or interactions (e.g., “teacher decision-making,” “material adaptation,” and “VIC feedback”). In the second phase, these initial codes were organised into broader categories and subcategories, highlighting relationships among codes and aligning them with key components of the activity system (e.g., subject, object, tools, rules, community, and division of labour). For instance, codes related to "teacher decision-making" and "material adaptation" were grouped under the overarching theme of "pedagogical design capacity." In the final stage, abstraction, the analysis focused on pinpointing the core themes central to the research questions. These themes formed the basis of a narrative that elucidated the co-design process and its outcomes. For example, the theme of "expansive learning" illustrated how teachers and designers generated new knowledge and practices through their collaborative efforts. Through careful synthesis, the findings were contextualised within broader discourses on participatory design and inclusive pedagogy, providing insights into the relational dynamics between teachers, designer, and VIC.

4.7.3 Video Analysis

Video recordings provided a rich data source, capturing the complex, multimodal interactions of subjects, objects, and materials. Before manually transcribing the recordings, I watched them without sound to reacquaint myself with moments I may have overlooked while serving as a designer during the co-design workshop. Although transcribing verbal and non-verbal exchanges was a labor-intensive task, I deemed it essential for producing the "thick descriptions" featured in the findings. Following Heath et al.'s (2010) iterative approach to reviewing video data, the analysis comprised three stages: (1) a preliminary review, (2) a substantive review, and (3) an analytic review.

Preliminary review

In this initial phase, the goal was to catalog the materials by providing a broad overview of the data corpus. A few days after the co-design workshop, I began by creating content logs in an Excel document. Informed by the cataloging suggestions from Heath et al. (2010), each log entry consisted of five columns: (1) dataset name, (2) timestamp of the event, (3) participant codes, (4) brief event description, and (5) reference to the relevant video recorder files.

Substantive Review

This review stage involved three sequential steps. First, I repeatedly watched the entire set of videos to gain a comprehensive perspective on the data corpus, recording my initial impressions as I became more familiar with its content. According to Wang and Lien (2012), adopting such an approach before coding guards against allowing a single noteworthy event to unduly influence subsequent analysis. Second, I transcribed the video data into Excel files. This transcription was interpretive in nature, requiring choices about the level of detail to include as I grew increasingly attuned to the data (Lapadat & Lindsay, 1999; Tilley, 2003). Multiple rounds of review and correction were conducted until I arrived at a final transcript suitable for analysis. Third, I identified “hot spots,” defined by Jordan and Henderson (1995, p. 43) as “sites of activity for which videotaping promises to be productive.” Here, I used concise descriptive markers to note significant events, specifically focusing on instances related to the co-design process and the use of materials. Through repeated, close examination of the video recordings, I catalogued and labeled such occurrences accordingly (Table 4.11).

Table 4.11. Example (workshop 2) of the substantive review of the video data.

Time	Participants	Utterance	Additional details
00:24:05	T, D, C2	Give me some cotton.	**(hot spots)** The designer was taking pictures and the teacher and the child’s parents provided timely help.
00:24:09	T, D, C2	Teacher, look at my ocean.	**(hot spots)**The teacher was explaining the materials and the designer came up to check the progress of the creation.
00:24:29	T	We have little white foam balls that can be glued with coloured play dough so that they can be turned into a pretty little fish.	Some children stopped what they were doing to listen to the teacher, some were making it at their own pace.
00:24:36	T	Anyone else want cotton.	No one responded.
00:25:12	C5	I don't have any more.	

Analytic Review

The analytic review served to refine the emergent analysis from the substantive phase.

In this stage, I conducted repeated searches through the entire dataset to locate similar instances for comparison. Concurrently, I performed a final review informed by the CHAT framework (see Table 4.12). This approach enabled me to compare the video-based findings with the results of the content analysis and identify “candidate instances” (Heath et al., 2010, p. 65). Such instances remained under consideration until I had developed a robust understanding of their features and overall organization. This final step fortified the coherence between the video analysis and the broader theoretical lens applied throughout the study.

Table 4.12. Example (workshop 2) of the analysis with CHAT components.

Time	Participants	Instances	Materials	Subject	Object	Rules	Community	Division of Labour
00:16:17	T, D, C4, C9	Co-creation	√	√			√	√
00:17:18	T	Key progress		√		√		
00:24:05	T, D, C2	Interacting with materials	√	√				
00:35:50	C3	Familial insights				√	√	
00:36:27	C4, C5	Peer conflicts					√	
00:42:05	C1	Parental conflict					√	

4.8 Trustworthiness

Trustworthiness, a concept central to qualitative inquiry, establishes the accuracy of findings from the perspectives of the researcher, participants, and scholarly audiences, while justifying their intellectual significance (Creswell, 2014, p. 196; Lincoln & Guba, 1985). Lincoln and Guba (1985) reconceptualized traditional notions of rigour by introducing trustworthiness as a framework for qualitative validity, prioritising credibility (the resonance of findings within their context) over conventional validity, and dependability (the consistency of methodological tools) over reliability. A persistent critique of qualitative case studies concerns their limited generalisability (Tight, 2010), a challenge this research addresses through deliberate methodological safeguards. Table 4.13 synthesises the strategies employed to ensure trustworthiness across four dimensions: credibility, transferability, dependability, and confirmability.

Credibility was fortified through prolonged immersion in the field (China) and methodological triangulation. Interviews, observations, document analysis, prototyping, and workshops generated multilayered data, mitigating the distortions inherent in single-method approaches (Cohen et al., 2011, p. 112). Cross-validation emerged from engaging diverse stakeholders—teachers, experts, and VIC participants—whose perspectives enriched the interpretive depth of findings. Longitudinal engagement over one semester further bolstered credibility by capturing temporal dynamics of social practices, a process termed prolonged engagement (Lincoln & Guba, 1985). This temporal breadth countered the limitations of static, single-moment studies (Cohen et al., 2011), while sustained interaction with participants enhanced the empirical grounding of conclusions (Savin-Baden & Major, 2013).

Case studies have long faced criticism regarding their generalisability (Yin, 2018). In response, Lincoln and Guba (1985) propose transferability, the applicability of findings to analogous contexts, was pursued through thick description (Lincoln & Guba, 1985). Detailed case narratives (Chapters 5–8) and explicit documentation of participant demographics (Section 4.5) enable readers to assess contextual parallels. As Bassey (2003) observes, transferability hinges not on universal claims but on a reader's capacity to gauge "relatability" (p. 45) through transparently rendered contexts.

Dependability and confirmability were ensured via iterative reflexivity and external audits. All instruments underwent rigorous review by supervisors and ethics committees, while peer debriefing during analysis and write-up phases surfaced latent assumptions. Presenting findings at the Design HDR Showcase (September 2024) and incorporating blind peer-review feedback further externalised interpretive logic, a safeguard against subjective overreach (Lincoln & Guba, 1985). Methodological transparency—explicitly detailing research choices, processes, and limitations (Savin-Baden & Major, 2013)—allowed readers to trace the chain of evidence.

As the primary "research instrument" (Maxwell, 2005, p. 83), my positionality, which shaped by disciplinary training, cultural background, and theoretical commitments, inevitably influenced study design, analysis, and interpretation (Merriam, 1998). This reflexivity is explicitly documented in Sections 1.1 and 4.4, inviting readers to critically evaluate how subjectivity intersected with empirical rigour. While qualitative inquiry inherently embraces the researcher's situated perspective (Savin-Baden & Major, 2013), ongoing critical self-appraisal and dialogue with supervisors ensured that assumptions were interrogated, not naturalised.

Table 4.13. Overview of the ways in which I addressed the trustworthiness of my research.

Measure of quality	**Methodological implementation**
Credibility	· Triangulation · Persistent observation · Prolonged engagement
Transferability	· Provision of thick description · Transparent description
Dependability	· Justification of research design processes · Detailed documentation of data · Peer debriefing · External reviewing
Confirmability	· Statement of researcher's values, background, and experiences · Peer debriefing

4.9 Ethical Considerations

This research adheres to the ethical protocols of the University of Leeds and the University of Sydney. Formal approval was granted by the University of Leeds Faculty of Arts, Humanities, and Cultures (FAHC) Ethics Committee (Ref: FAHC 22-097) prior to all fieldwork. Because the work involved children with visual impairment and cross-border fieldwork in China, approval proceeded in two stages: (1)

a core application covering child participation and accessibility safeguards, and (2) a fieldwork authorisation detailing conduct in China, local permissions, cultural considerations, and institutional collaboration. The application underwent two amendment rounds in response to committee queries (e.g., child assent procedures, withdrawal/decline protocol, and risk-mitigation steps tailored to VIC). From initial scoping to final approval, the process required approximately four months. The fieldwork authorisation included a context statement confirming familiarity with local customs and the educational setting, and evidence of collaboration with local partner (Bethel China). I documented local permissions, institutional endorsements, and facility access protocols. Instruments and procedures were pilot-checked with local teachers to ensure cultural appropriateness and feasibility. Scheduling respected institution calendars and family routines, and all communication with families was supported by bilingual materials where needed.

Upon transferring doctoral candidacy to the University of Sydney under continued supervision, consultation with its Ethics Committee confirmed that no additional review was required, as data collection had concluded under Leeds' ratified procedures. Data retention and management align strictly with the University of Sydney's Research Data Management Policy (RDMP). Ethical imperatives—encompassing research design, participant recruitment, confidentiality safeguards, anonymity protocols, and reflexive professionalism—permeated every methodological phase (Cohen et al., 2011).

Participants were recruited through Bethel China, a long-standing provider for VIC trusted by families. Gatekeepers (senior staff in institution) introduced the project to families and helped schedule activities to minimise disruption to schooling and care routines. From the outset, participants received comprehensive information about the research aims, data collection procedures, and anticipated outcomes. As described in Section 4.5, potential participants were contacted on multiple occasions and through various channels, with a clear emphasis on the voluntary nature of their involvement. Informed written consent (Appendix B) was obtained from each participant before data collection commenced. I implemented layered consent consistent with Leeds guidance on research with children:

- Guardian consent: guardians received an information sheet and consent form. The sheet explained the purpose, procedures, potential benefits/risks, data handling, and the voluntary nature of participation.
- Child assent: children were offered an age-appropriate explanation using plain speech and tactile exemplars of activities. Assent was affirmative and revisited before each activity block.
- Right to withdraw: guardians and children that they may withdraw from the study at any time before its conclusion without any consequences and may request the deletion of personally identifiable data.

Risk was assessed as low but not negligible (e.g., children's fatigue). Mitigations included: short, time-bounded sessions; frequent breaks; non-evaluative and play-based tasks; and the presence of familiar teacher/guardian. Any adverse event or safeguarding concern would be escalated to the Designated Safeguarding Lead at institution and, where applicable, via the University of Leeds reporting pathway, following local legal requirements. No adverse events occurred during data collection. Privacy, confidentiality, and anonymity were prioritised at every stage. Participants' personally identifying information was never disclosed (Savin-Baden & Major, 2013). Instead, each participant was assigned a unique identifier, ensuring ongoing protection of their identity. All participants were informed that anonymised quotes might be used in research reports to enhance the credibility of this qualitative study, and they provided their approval prior to data collection. In accordance with University of Sydney regulations, data were stored securely in password-protected repositories. Only I, the principal researcher, had unrestricted access to the raw and transcribed data; when sharing material with my supervisory team, I presented only anonymised excerpts to mitigate potential conscious or unconscious bias. No data were transferred to third parties. Further details on these ethical considerations can be found in Appendix.

4.10 Conclusion

This chapter has elucidated the hermeneutic scaffolding and epistemological coherence underpinning the methodological architecture of this study. It outlined the philosophical positioning taken, the rationale for a qualitative case study design, the iterative interplay between participant selection criteria and multimodal data collection strategies, it has rigorously justified the dialectical relationship between scholarly inquiry and procedural execution, and the ethical considerations. The analytical framework, synthesising inductive coding practices with deductive sensemaking, operationalised the tension between empirical particularity and theoretical abstraction—a tension further disciplined through Lincoln and Guba's (1985) trustworthiness criteria. The subsequent chapters turn to the findings of this thesis, offering a comprehensive analysis of the data collected.

5. Teacher as Designer

This chapter reconceptualizes teaching as a design practice (e.g., Eisner, 1983). It argues that, like designers, teachers interpret available resources, assess pedagogical constraints, balance trade-offs, and develop strategic designs to achieve their instructional objectives.

This chapter is from an article under review:
Rong, A. & Hansopaheluwakan-Edward, N. (2025). Co-design as Pedagogy: Understanding Materiality, Designed Form and Learning Activity with/for Visually Impaired Children. *Co-design*.

5.1 Introduction

This chapter describes how teachers make design decisions through the use of materials, thereby contributing their ideas to the VIC's learning experience. It primarily addresses **RQ1**: "*How do teachers conceptualise and implement design strategies in developing learning materials and activities for visually impaired children*?" The central theoretical concepts informing this question grounded in the socially situated context of learning and in the multi-level factors that shape design decisions, this chapter contends that the teacher's role as designer is inherently dynamic and transformative—continually evolving in a reflective process informed by interactions with VIC, colleagues, the object, and the broader community.

Observational data (observation guide found in Appendix E) serve as a key source of rich, real-time insights into how learning materials are used. This chapter also draws on a semi-structured interview study with teachers (list of interview questions can be found in Appendix D), analysed through thematic analysis, to identify how educators conceptualise and implement design strategies. By highlighting the processes through which teachers make and negotiate design decisions, as well as the various spheres of influence on these decisions, it offers a holistic view of teachers' design practices. Specifically, it illustrates the interrelated components of the design process, teachers' professional contributions and knowledge, and team-level perspectives. Additionally, the chapter explores the impact of community and institutional contexts on teachers' decision-making processes.

5.2 Teaching as Design for Learning

Moving beyond conceptions of pedagogy as a mechanistic procedure—characterised by the transmission of static knowledge or the rectification of deficiencies—the designer metaphor illuminates how participants reconceptualized teaching as a creative and affective undertaking. Within this framework, educators emerge not merely as instructors but as architects of meaning, actively fashioning their professional identities (that is, interrogating and redefining the ontological contours of "teacherhood"). This designer theme is articulated through two explicit metaphors: one of the designer per se, and the other of "a craftsman" (Poole, 2024).

In this section, I argue that educating VIC necessitates a deeper investment in the planning phase, with teachers' preparatory work increasingly embodying the characteristics of design for learning (Table 5.1). This contention is both a design-oriented and an educational argument. I maintain that traditional methods—teaching in the same manner in which one was taught—are ill-equipped to address the evolving challenges confronting inclusive pedagogy. By contrast, a strategic reallocation of resources toward design for learning offers a viable pathway to enhance the quality of education for VIC within limited resources. Moreover, I contend that devoting more time to design will empower individual educators and collaborative teaching teams to better manage the escalating pressures on their work, thereby creating superior learning opportunities for VIC. Correspondingly, designers that develop more robust support systems for the design efforts of teachers will be better positioned to meet the changing needs of VIC. Nonetheless, it is important to recognise that design is not a panacea; designers can and do err. Yet, educational discourse increasingly notices the heuristic value of design methodologies—particularly their capacity to grapple with complexity, mediate competing imperatives, reframe intractable problems (Goodyear, 2015), and engage stakeholders (students as co-designers, rather than passive recipients) in iterative processes. While design cannot promise resolution, it provides a discursive and practical toolkit for reimagining pedagogy as a dynamic, relational practice—one that mirrors the ambiguities and aspirations of inclusive pedagogy itself.

Table 5.1. Overview of the themes, activities, and pedagogical design strategies for learning.

Section	Activity	Themes	Strategies	Object (Pedagogical Goals)
Designed as adaptive	Core activities	- Adaptive intentionality - Embodied cognition - Sensory-learning integration	- Pre-designed activities with embedded responsiveness - Structured exercises using tactile materials - Teacher-directed exercise tasks	- Refine spatial awareness - Develop motor coordination - Build tactile understanding of abstract concepts
Designed as contingent	Emergent activities	- Contingent design - Real-time adjustments - Tactile understanding	- Dynamic elaboration of activities based on VIC's responses - Adjusting tactile materials - Tailoring tasks to individual needs	- Cultivate tactile sensitivity - Foster exploratory agency - Enhance fine motor skills
Design as routine	Routine activities	- Routine-based design - Spatial and temporal continuity - Sensory inclusivity	- Personalised object markers for belongings - Tactile certificates of achievement - Structured daily practices	- Foster independence - Strengthen haptic memory - Mitigate disorientation
Design as unavoidable	Extraneous activities	- Unplanned external events - Serendipitous co-creation - Improvisational pedagogy	- Corporate staff visits - University clubs interactions - Temporary art exhibitions	- Encourage autonomy - Expand sensory and aesthetic experiences - Foster collaborative engagement
Design as necessary	Infrastructural activities	- Logistical necessity - Material hermeneutics - Sensory improvisation	- Teacher-designed schedules using real objects - Tactile designs	- Provide tactile guidance for daily routines - Bridge cultural events with sensory accessibility

5.2.1 Designed as adaptive

The observational data reveal that core learning activities for VIC are architectonic—that is, deliberately structured yet dynamically responsive. Teachers do not merely adapt to VIC behaviour; they engage in adaptive intentionality, pre-designing activities with embedded responsiveness to proprioceptive and auditory feedback loops. Crucially, "designed" here denotes a hermeneutic process that is intentionally planned: the teacher-as-designer encodes pedagogical possibilities through material-semiotic assemblages (structured exercises, tactile materials, movement protocols) that mediate between VIC's embodied cognition and curricular objectives. In Figure 5.1 and Figure 5.2, for instance, teachers facilitate sensory-motor activities using structured exercises—sometimes employing physical materials, at other times relying on teacher-directed, movement-based tasks. Such activities foreground the embodied nature of VIC learning by integrating bodily interaction into cognitive and conceptual development. Through real-time engagement with tangible materials, guided motion, and contextual feedback, students refine spatial awareness, develop motor coordination, and build tactile conceptions of abstract ideas. This adaptive instructional approach reflects the teacher's role as an intentional designer who customises learning experiences to satisfy diverse sensory needs while maintaining pedagogical coherence.

Figure 5.1. VIC choose their preferred toys/exercise equipment according to the teacher's arrangement in the sensory classroom.

Figure 5.2. VIC doing exercises led by teachers.

Figure 5.3 presents a thematic lesson titled The Lively Market, conducted in July, 2023, in which parents contributed fresh food from home, including meat, fruits, and vegetables. The children's differential responses—attraction to fruits' aromas, perplexity at coriander's smell—were pedagogically reframed through the teacher's prerecorded market soundscape (the sound of Alipay payment arrival, the shouts of vendors, ambient chatter). This multimodal design enacted a haptic hermeneutic circle: VIC decoded the thematic environment through layered sensory inputs (tactile produce examination ↔ auditory narration ↔ olfactory categorisation), constructing meaning via cross-modal synthesis. Meanwhile, through guided inquiries (e.g., prompting VIC to recognise and describe market sounds), the lesson promotes language development, and fosters a situated understanding of communal environments. Here, the classroom transformed into a simulated marketplace; the design extends beyond direct sensory-motor engagement to incorporate thematic contextualisation that reinforces meaning-making through tactile exploration and auditory cue.

Figure 5.3. Tactile identification of vegetables.

These core learning activities position VIC pedagogy as a dialectic between embodied schematism (somatic engagement with designed artifacts) and diegetic environmentalism (narrativized sensory immersion). The teacher thus operates as a diegetic designer—simultaneously engineering tactile materials and constructing multisensory narratives that place students at the centre of epistemic “storyworlds.” This dual praxis rejects a simplistic division between “concrete” motor skills and “abstract” thematic understanding; instead, it underscores that for VIC, abstraction remains inherently embodied, mediated by carefully orchestrated material and auditory encounters.

5.2.2 Designed as Contingent

Emergent activities, while grounded in a pre-established pedagogical framework, exemplify the contingent nature of teaching as design. These learning activities are not rigidly scripted but are dynamically elaborated in response to the real-time performance and sensory engagement of VIC. Such *contingency* reflects a dialogic process where the teacher interprets and refines the learning trajectory based on VIC's embodied interactions and emergent needs. Such an approach underscores the teacher's dual role as both designer and improviser, crafting activities that are simultaneously structured and fluid, intentional yet contingent.

Figure 5.4. The teacher adjusts the tactile materials according to the child's response.

Figure 5.4 illustrates the thematic course Touch Anywhere, a paradigmatic example of contingent design. Here, the teacher introduces tactile objects drawn from everyday life, selecting and adjusting materials based on the children's immediate responses and sensory capacities. The activity's objective is twofold: to cultivate tactile sensitivity and hand-foot coordination, and to ignite curiosity and exploratory agency. By allowing children to engage with diverse textures—ranging from smooth surfaces to coarse fabrics—the lesson transforms tactile sensation into an epistemic modality. The children's hands even feet become hermeneutic tools, deciphering material properties and constructing meaning through haptic exploration. This process not only enhances sensory skills but also fosters a tactile imagination, enabling children to conceptualise abstract ideas (e.g., texture gradients, material durability) through direct physical engagement.

Figure 5.5. The teacher adapts fine motor exercises to the abilities of the VIC.

Figure 5.5 shifts focus to fine motor skill development, showcasing another facet of contingent design. The teacher tailors materials to individual needs, offering strings of varying thicknesses, beads of different sizes, and plastic mushroom pegs. This differentiation reflects a pedagogy of care, where design decisions are informed by the unique sensory and motor profiles of each child. The activity's iterative nature—children practice threading, grasping, and manipulating objects—the teacher scaffolds tasks to challenge but not overwhelm, ensuring that each child progresses at their own pace.

Taken together, these emergent activities illustrate how contingent design operates as a tactile epistemology. The teacher's real-time adjustments—whether in material selection, task complexity, or sensory feedback—transform the classroom into a laboratory of embodied learning. This approach not only accommodates the diverse needs of VIC but also positions them as co-designers of their learning experiences. By foregrounding contingency, the teacher resists the rigidity of pre-determined curricula, instead embracing a pedagogy that is as fluid and responsive as the sensory worlds it seeks to illuminate.

5.2.3 Design as routine

The design of routinised activities constitutes an essential yet often overlooked dimension of pedagogical practice, particularly in contexts involving VIC. While these activities may not directly align with core instructional objectives, they play a pivotal role in structuring daily practices—shaping the material and procedural conditions that enable VIC to navigate their educational environments with autonomy. Routine-based designs are not merely logistical; they are supportive, embedding predictability into the lived experience of VIC and fostering a sense of spatial and temporal continuity. Through these practices, teachers emerge as designer of habitus, crafting environments that balance stability with sensory inclusivity.

Figure 1.6 exemplifies an innovative approach to object identification, addressing the unique challenges VIC face in locating personal belongings. Unlike their sighted peers, who can rely on visual memory for object retrieval, VIC must construct spatial and tactile schemas to orient themselves within their surroundings. To support this process, teachers designed personalised object markers for each child. These tactile markers serve as unique identifiers for each child's belongings, including their shoes, chairs, and water cups etc. Through consistent exposure and guided practice, VIC internalise these markers as part of their spatial cognition, gradually developing an intuitive familiarity with their physical environment. This pedagogical intervention extends beyond mere convenience; it fosters independence, strengthens haptic memory, and mitigates the disorientation that can arise in visually intensive settings.

Figure 5.6. Object-name checklist for each visually impaired child.

Figure 5.7. Object markers on shoe shelves and chairs.

Similarly, Figure 5.7 captures the practical application of these object markers within the institution. Here, VIC locate their designated items by recognising their assigned markers, reinforcing their ability to navigate shared spaces autonomously. This process not only enhances their spatial awareness but also instills a sense of personal agency, as they no longer require external assistance to perform fundamental daily tasks. The routinisation of such practices transforms the learning environment into an accessible and navigable domain, wherein VIC can operate with ease.

Beyond object identification, the design as routine extends beyond spatial navigation to encompass affective reinforcement, as exemplified in Figure 5.8. Here, teachers employ tactile certificates of appreciation to recognise student achievements. Unlike conventional certificates, which privilege visual aesthetics, these awards are designed with sensory inclusivity at their core. Featuring Braille and tactile design elements, they render achievement legible through touch, ensuring that VIC can fully engage with their symbolic value. By allowing VIC to “read” their own accomplishments through touch, the certificates transcend their function as mere symbolic rewards, becoming meaningful artifacts of recognition that resonate with the sensory realities of VIC.

Figure 5.8. At the end of the course the VIC held up their certificates and took picture with the teachers.

5.2.4 Design as Unavoidable

Within institutional settings, certain external events arise spontaneously, operating beyond the sphere of planned instructional design. These occurrences—such as corporate staff visits, university charity clubs engaging with VIC, or research teams conducting observational studies—are not deliberately crafted by teachers, nor do they form part of a structured pedagogical agenda. Instead, they constitute unpredictable yet influential elements that shape the learning in unanticipated ways. It is precisely their unplanned nature that renders them distinct from other forms of activities. Therefore, I did not classify such occurrences as “designed as unavoidable”—since design inherently implies intent—these external interventions are nonetheless integral to the institutional learning ecosystem. Thus, I categorise them as “design as unavoidable,” acknowledging their incidental yet undeniable impact on educational experiences.

Figure 5.9. The VIC sang songs with the employees of the companies that visited the institution, and the VIC tried to accompany them with the instruments they were good at.

Consider Figure 5.9, which captures a moment of serendipitous co-creation: corporate employees engage with VIC in a collaborative musical session. The children are encouraged to select their favourite songs and instruments, transforming an unplanned visit into an interactive, participatory experience. While the event itself is not part of the curriculum, it offers an organic opportunity for VIC to explore rhythm, melody, and collaborative engagement through sound, touch, and sociality. Unlike teacher-designed activities, which are structured with explicit learning objectives, such moments unfold spontaneously, fostering an environment where VIC exercise autonomy in unavoidable decision-making.

Figure 5.10 University students from the University Community Service Society are teaching VIC to create visual art.

Similarly, Figure 5.10 illustrates a visit by university students from a community service club, who introduce VIC to artistic expression. Though external visitors may lack the pedagogical expertise of trained instructors, their presence injects novelty into the classroom, exposing VIC to new materials, methods, and perspectives. These interactions, though unintended in the strict sense of instructional planning, nevertheless contribute to the children's aesthetic and sensory experiences, expanding their engagement with tactile and visual art.

Figure 5.11 extends this design of unavoidability into the material realm. A "temporary exhibition" of VIC's artworks, hastily arranged in a corridor, transmutes an institutional thoroughfare into an epistemic gallery. This exhibition, precipitated by external visitors, reconfigures the spatial recognition. The corridor, once a liminal space, becomes a site of visibility—albeit one mediated through tactile and auditory engagement—for works that might otherwise remain confined to the classroom.

Figure 5.11. An exhibition of visual art created by the VIC, set up by the teacher in the corridor outside the classroom.

These vignettes collectively underscore a critical tension: while design aspires to coherence, pedagogy is perpetually reconstituted through unplanned encounters. The teacher, here, is not only a designer but a bricoleur—improvising within the interstices of contingency, negotiating the unforeseen without relinquishing pedagogical agency. In this light, "unavoidable" events are neither flaws nor distractions but constitutive fissures in the fabric of design. They expose the limits of pedagogical control while affirming the generative potential of the unplanned. To teach, then, is to inhabit this paradox: to design with intentionality while remaining hospitable to the hermeneutic richness of the undesigned.

5.2.5 Design as Necessary

In the educational landscape of VIC, certain foundational operations exist outside the realm of direct pedagogical intent. These infrastructural activities—such as the preparation of teaching aids and the arrangement of the learning environment—are not primarily driven by instructional objectives but are nonetheless indispensable to the classroom’s smooth functioning. Their necessity arises not from pedagogical innovation but from logistical demands, ensuring that the learning space remains structured, accessible, and conducive to engagement. While these activities do not directly contribute to the cognitive development of students, they establish the infrastructural conditions that enable meaningful learning experiences.

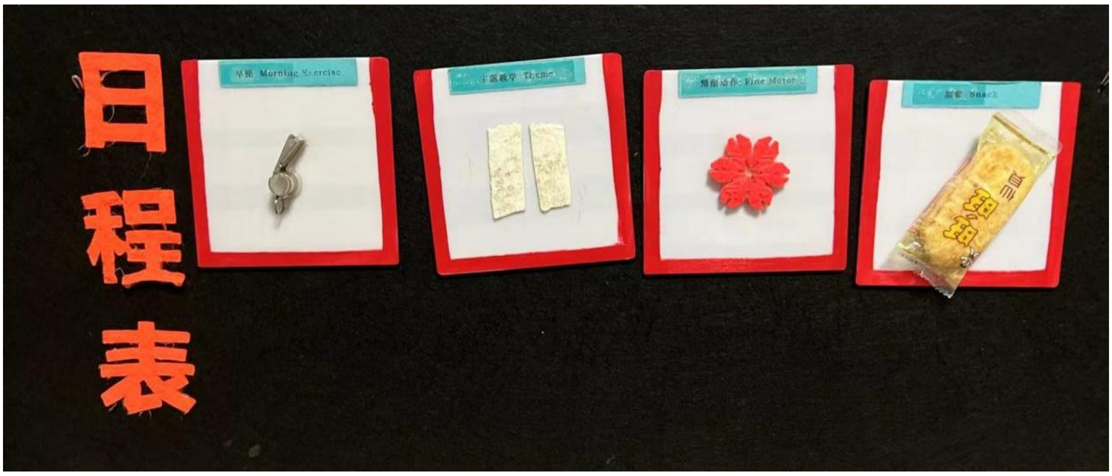

Figure 5.12. Teacher-designed schedules (using real objects) based on children’s preferences.

Figure 5.12 illustrates a teacher-designed daily schedule that employs real objects to signify different segments of the school day. Unlike conventional visual schedules, which rely on text or pictorial representations, this schedule incorporates tangible objects—each symbolising a specific routine or event. For example, the children’s favourite Wangwang shrimp cracker represents snack time, while thematic elements are adapted to align with the monthly curriculum focus. This physicalized representation of time and routine serves a dual function: it provides VIC with a tactile guide to their daily activities while reinforcing memory through sensory association. Rather than abstractly conceptualising time through visual cues, VIC engage with a materialised structure of daily sequencing, fostering independence and orientation within the classroom environment.

Figure 5.13. Teacher-designed sports logos made by matches.

Figure 5.13 extends this logic into the realm of symbolic representation. During the Olympic Games, teachers created sports logos using matches, arranging them into tactile emblems of athletic disciplines. This activity, though not strictly instructional in the conventional sense, reflects a logistical design ethos—one that transforms an abstract event into a tangible, haptic experience. By crafting these representations, teachers bridge the gap between cultural events and sensory accessibility, allowing VIC to engage with broader societal narratives through touch. These designs, while peripheral to direct learning outcomes, contribute to the environmental semiotics of the classroom, embedding familiarity and contextualisation into daily interactions.

Yet these designs also expose a tension: the infra-activity's necessity derives not from pedagogical innovation but from institutional convention. The teacher's ingenuity lies in subverting this constraint, transforming logistical mandates into opportunities for sensory improvisation. In doing so, they resist the bifurcation of "core" and "peripheral" design, asserting that even the most utilitarian tasks participate in the broader aisthetics of the classroom—the distributed network of sensory stimuli that tacitly structures learning. Ultimately, infra-activities challenge the hierarchical privileging of "direct" instruction over "ancillary" labour. They affirm that accessibility is not a supplementary concern but a material ethic, woven into the very infrastructure of pedagogical space.

5.3 Design for Orchestration

Designing for orchestration entails structuring the dual flow of information between content (the 'what' of learning) and mediating artifacts (the physical materials used), thereby shaping how VIC engage with, process, perceive, and internalise knowledge. In practice, this workflow integrates core learning activities alongside other activities (emergent, routine, extraneous and infrastructural). In addition, this section will specifically discuss the factors that influence teachers' design decisions. The thematic analysis of teacher interviews led to five main themes that collectively address RQ1 (Table 5.2). These themes elucidate both the strategies of teacher decision-making (Theme 5) and the spheres of influence shaping those decisions (Themes 1–4).

Table 5.2. Themes and sub-themes from analysing the data in the interviews with teachers.

Themes	**Sub-themes**
1. Understanding Children's Needs (*Variability*)	· Observation and daily interaction · Communication with parents and home visits · Recognising emotional cues and responses · Personalised learning through recorded progress · Using multisensory approaches to assess children's needs
2. Challenges in Teaching VIC (*Ambiguity*)	· Memory retention difficulties · Limited verbal communication · Emotional resistance and shutdown during lessons · Difficulty conceptualising abstract visual ideas · Lack of standardised teaching aids and materials · Parents' expectations and educational misalignment
3. Role of Teachers and Collaboration	· Team-based curriculum development and planning · Collaboration with parents for at-home reinforcement

(*Uncertainty*)	• Teacher training, mentorship, and knowledge sharing • Interdisciplinary collaboration challenges • Adapting teaching methods through feedback
4. Cultural-Historical Influences and Systemic Issues (*Restrictiveness*)	• Societal perceptions and misconceptions about VIC • Institutional resource constraints in specialised education • Limited access to early intervention programmes • Need for structured networking among professionals • Barriers in implementing inclusive education policies
5. Strategies for Teaching and Material Development (*Adaptation*)	• Multisensory teaching approaches (tactile, auditory, kinesthetic) • Use of real-life objects and tactile learning aids • Music and sound-based reinforcement • Repetitive and reinforcement-based learning • Customising materials based on student feedback • Role-playing and experiential learning methods

Specifically, understanding children's needs informs the foundation of design strategies by emphasising teachers' reliance on observation, parental input, and direct engagement to tailor learning experiences based on individual emotional and cognitive responses. Second, navigating challenges—such as memory retention deficits, communication barriers, and material standardisation gaps—compels iterative, improvisational design strategies. Third, collaboration reveals the ways in which teachers engage in co-design with parents, colleagues, and experts, iterating on materials and methods to align with children's evolving needs. Finally, systemic issues and cultural-historical influences underscore how institutional limitations, societal perceptions, and policy gaps constrain the feasibility of certain design strategies—reveal how macrostructural contradictions (per CHAT) constrain pedagogical innovation, necessitating advocacy alongside adaptive resilience.

5.3.1 Variability

The process of identifying the needs of VIC is neither uniform nor static but rather an intricate interplay of observation, interpretation, and adaptation. The accounts presented by teachers in the interview transcripts illuminate the variability of this process, where knowing is not a mere act of acquisition but one of continuous co-construction with the child, their caregivers, and the broader learning ecology.

One of the most striking elements in teachers' interviews is the heterogeneity of observational methodologies. Teachers describe a multifaceted approach to discerning special needs: they emphasise initial briefings by senior teacher, in-depth communication with parents, and home visits that yield contextual knowledge of each child's interests, routines, and potential allergens. Daily observation also emerges as essential, as teachers carefully attend to children's emotional states and reactions in real time:

> "Usually, by spending two or three days with a child or simply observing them for one day can reveal a lot. For instance, if their behaviour is unusual one day, it could be because they are upset or didn't sleep well. In these 4 months, I have roughly understood every child and got a grasp of each of their characteristics." (T1)

Yet, this process remains contingent upon the child's disposition, affective states, and communicative capacities—particularly for those with additional cognitive impairments who cannot immediately signal their needs in legible ways. Parental mediation further complicates this interpretive process, often requiring teachers to reconcile parental assessments with their own classroom observations:

> "For VIC, I believe they can cope relatively easily in the early childhood education stage. However, as they age, especially in their school years, the pressures faced by both them and their parents increase, particularly the pressure of accompanying their studies.[...] This true maternal love and acceptance isn't something everyone can offer. Of course, there are other parents willing to make all sorts of sacrifices for their child's future, including financial contributions or even searching for schools in cities like Beijing. However, every child and family has a unique situation, and this holds true in the cases I've encountered." (T2)

The pedagogical goal extends beyond the institution's physical and ideological boundaries, reaching into the domestic sphere, where parental knowledge functions as both a supplement and an interruption to institutional expertise. Also, while homes visits provide crucial insights into children's histories and comfort zones, they also introduce another layer of variability, as parental assessments are often shaped by their own anxieties, aspirations, and social expectations. In some cases, educators must mediate between conflicting representations of the child—the one presented by the parents and the one that emerges through direct observation.

Moreover, the material conditions of perception play a decisive role in structuring variability. Teachers describe the significance of sensory cues in navigating children's needs: "*...recognising the child's emotional cues, such as their reactions to different situations, to determine their comforts or discomforts* (T5)." Yet this affective legibility is inherently unstable: children's emotional responses vary according to bodily rhythms, environmental factors, and relational interactions. A child who delights in an activity one day may withdraw the next, demanding constant recalibration of the teacher's interpretive frameworks.

In this regard, the teachers' narratives articulate a dialectic of structure and contingency: while they establish observational protocols, maintain records, and refine their practices through experience, the unruliness of human difference continually unsettles these systems of knowing. This *variability* is not a failure of pedagogical design; rather, it reflects an educational paradigm that prioritises relational attunement over rigid diagnostic norms. It also reflects a contradiction within the activity system: the pedagogical drive toward predictability and systematisation exists in tension with the irreducible singularity of each child's way of being in the world. Thus, variability in understanding children's needs does not merely denote inconsistency; rather, it marks the fundamental openness of the learning encounter—an openness that demands from teachers not only methodological rigour but also an attunement to the epistemic limits of their own knowing.

5.3.2 Ambiguity

If variability in understanding VIC's needs arises from an epistemic fluidity, then the pedagogical challenges teachers face reveal an even deeper realm of ambiguity—a space in which certainty dissolves, and the very foundations of teaching are shaped by the unpredictable, the indeterminate, and the resistant. This ambiguity points not only to contradictions within the activity system—between standardised curricula and children's special cognitive trajectories, between pedagogical authority and child agency—but also to the limits of knowledge itself, as teaching becomes a continual negotiation with what resists assimilation into existing frameworks of learning.

A primary locus of this pedagogical ambiguity is memory retention. As one teacher remarks,

> "...they might only retain about 10% of what is taught, and perhaps they will forget it the next day. Like C9, we teach him to use his hand to protect himself while walking, and even though he follows our instructions at first, he might forget later on. " (T1)

The tentative phrasing—"perhaps"—registers not only uncertainty but also a resigned acknowledgment that memory does not function as a stable repository; instead, it operates in unpredictable rhythms, slipping between moments of acquisition and erasure. Such ambiguity does not merely frustrate pedagogical design but forces educators into a mode of perpetual recalibration, wherein repetition and reinforcement become not just strategies but necessary conditions of teaching itself. Also, the ephemeral adherence to instruction—where learning seems to take hold momentarily before dissipating—reveals the instability of habit-formation in children whose cognitive processing follows non-normative pathways. The uncertainty here is not simply about whether the lesson is absorbed but about how knowledge itself is structured in a mind that does not conform to conventional pedagogical expectations. The teacher's phrasing—"he might forget"—suggests that the pedagogical act is always haunted by its potential undoing. Another teacher reflects on this predicament,

> "The biggest challenge is that, even after we invest a lot of time and energy in coaching them, they might not show noticeable feedback or change. This situation could be due to our strategies or other environmental factors. When we can't find a breakthrough, feeling confused and frustrated is natural. Especially for children who seem 'apathetic', providing them with any resources or encouragement seems ineffective. They might appear uninterested in everything, maybe even just wanting to play alone. Conversely, those who express emotions easily, like crying or throwing tantrums, are relatively easier to understand and manage since they externalise their emotions instead of completely shutting themselves in." (T2)

Therefore, ambiguity also manifests in the domain of non-verbal communication, where the very act of gauging a child's comprehension becomes speculative. As T5 explains, "*for kids like C17 who don't speak, teaching them becomes a challenge because we don't know if they're understanding anything*." Pedagogical success is traditionally measured through response and articulation, yet here, silence itself becomes a site of radical unknowability. Does non-responsiveness indicate a lack of comprehension, a refusal to engage, or a cognitive process occurring outside the bounds of linguistic expression? Teaching thus shifts from a didactic act to an exercise in speculative interpretation, where meaning remains always uncertain, contingent, deferred.

Beyond the individual child, ambiguity is compounded by external forces—namely, the expectations and anxieties of parents. T8 notes the challenge of discrepant parental perspectives: "*Parents' expectations can sometimes misalign with the educators' assessments of the child's abilities, leading to disagreements in educational direction*." Ambiguity operates at the intersection of social, cultural, and institutional forces, where competing claims to knowledge—those of parents, teachers, and the children themselves—produce friction and epistemic instability. What one party deems progress, the other might perceive as stagnation; what the teacher understands as a necessary pedagogical limitation, the parent may view as a failure of the educational system itself.

Finally, ambiguity pervades the affective sphere of teaching, where teachers must navigate not only the cognitive challenges of their students but also their own emotional investments and uncertainties. As T6 reflects, “some children might completely shut themselves off, making it challenging to establish a connection or bond.” This sense of disconnection, of teaching into a void of unresponsiveness, marks one of the most profound existential ambiguities of special education: what does it mean to teach when one remains unsure of ever being ‘received’? Sustaining the emotional labour of care and dedication becomes all the more challenging when the very notion of progress is destabilised by the child’s unpredictable responses.

5.3.3 Uncertainty

To teach is not simply to transmit knowledge; it is to navigate a shifting landscape of relational, institutional, and epistemic uncertainty. This dynamic is particularly visible for educators working with VIC, whose pedagogical practices extend beyond the classroom to encompass negotiations of expertise, fluid models of collaboration, and the affective economies of care. Within the framework of CHAT, teachers’ experiences illuminate contradictions within the activity system, particularly in how roles are distributed, how knowledge is co-produced across institutional and domestic spheres, and how authority is both claimed and contested. In this pedagogical landscape, uncertainty is not incidental but foundational, shaping how teachers conceptualise their own professional identity, their collaborations with parents and specialists, and their ongoing recalibration of teaching strategies.

One notable articulation of this uncertainty lies in the instability of pedagogical authority. While teachers are conventionally seen as the primary source of expertise, their accounts reveal a far more tentative, fragmented, and at times precarious relationship to knowledge.. As teachers state,

> “We have a team. Firstly, the theme lesson for each month is set through teamwork,

> headed by T2. After drafting the teaching plan, she discusses and refines it with other teachers. Judy, a teacher from Shanghai originally from Taiwan, also participates in reviewing and providing suggestions." (T4)

> "Only with a comprehensive and systematic education and service system can we ensure that children receive consistent and effective assistance. Otherwise, all efforts may seem fragmented and ineffective." (T8)

The description of pedagogical planning is a collective enterprise rather than an autonomous exercise of pedagogical power. The teacher's authority, therefore, is subject to multiple perspectives, critiques, and revisions. Far from standing as a solitary architect of knowledge, the teacher occupies a co-constructive role—negotiating content within an ongoing, sometimes contested, dialogue.

Such collaborative structures do not necessarily resolve uncertainty; rather, they reinscribe it through a confluence of voices, priorities, and theoretical paradigms. This intersection of perspectives is especially salient in teacher-parent relationships, where pedagogical authority is further mediated by parental expectations. As teachers note,

> "The cooperation of parents is crucial. They are an essential auxiliary force in the teaching process. For example, we would assign some homework, allowing children to practise at home. If we've learned about the concept of "one" in class, parents could help their kids at home by finding similar objects, such as vertical twigs or sticks, to reinforce understanding. We also have a parents' group where the head teacher sends related materials and music to the parents, encouraging them to practise more at home. Some parent, like C19's grandmother, is very dedicated and teach her child based on the teacher's guidance." (T1)

> "Parents are often in a continuous process of searching and self-learning, lacking stable and ongoing educational support. Compared to some developed countries like the UK and the US, where the roles of parents and teachers are more defined and can continuously receive systematic services, there's a significant gap with our situation." (T8)

While these statements underscore the value of parental involvement, it also reveals a state of mutual dependence. Education, particularly for VIC, cannot be confined to school settings but depends on reinforcement, interpretation, and collaboration within the home. Yet reliance on parents introduces a structural instability: if home-based reinforcement diverges from school strategies, the educational process becomes an uncertain amalgam of competing influences. Uncertainty thus arises not solely from pedagogical practice but from the interplay of multiple systems, each contributing its own constraints and resources.

Moreover, uncertainty is amplified in interdisciplinary collaboration, where teachers must engage with specialists, caregivers, volunteers, and institutional policies that do not always cohere. One teacher reflects on this difficulty, stating,

> "Challenges in interdisciplinary collaboration often arise, particularly when resources are limited. I hope there will be a more professional team to serve these children. Many parents have not fully accepted their own child. Currently, everyone: parents, society, teachers, and the country (disability organisations) are not on the same page regarding this matter. Only a truly professional team can deeply understand and meet the needs of these children. However, in reality, many voices in society are sceptical, questioning the real value of such services. In our country, many people assess the value of things based on direct results and returns. Thus, when faced with seemingly 'niche areas', they believe it's not necessary to invest and research. For instance, when investing in special education research, they often question its true value and meaning. In many people's eyes, the resources invested should yield an equivalent return. If ten years of effort only cultivates ten students, they deem it unworthy. Society generally believes that our resource allocation should be based on 'quantity' and 'benefits', leading to the neglect of some special groups." (T8)

In this scenario, uncertainty transcends interpretive ambiguity to become an institutional condition, shaped by funding structures, expertise gaps, and systemic skepticism. Teachers find themselves translating and mediating among diverse professional vocabularies, knowledge claims, and policy mandates—all while maintaining their immediate pedagogical duties. The teacher's role thus expands beyond instruction to include an ongoing process of negotiation in a context of limited resources and conflicting objectives.

On an affective level, this uncertainty manifests in teachers' own sense of purpose and the indeterminate outcomes of their efforts. Though their practice is grounded in care and relational engagement, an underlying awareness remains that success is difficult to quantify and progress cannot be reliably mapped. The teachers acknowledge this explicitly,

> "We rely on feedback over time and one must have patience to understand because the results aren't immediate. I teach self-care, and for some children, it took 5 years just to practise eating. They required feeding, and even if they went hungry for a day, they wouldn't eat on their own. They can speak, but they simply don't want to eat by themselves." (T5)

> "We might initially design a simple version of a teaching tool. However, upon its actual use, we may find that modifications or refinements are needed to better meet educational requirements. Some materials might be too heavy or inconvenient to place on a table during lessons, prompting us to consider alternative lightweight materials, like light clay, for redesigning or enhancing them. In fact, we have dedicated teachers every month who craft and optimise teaching materials. Their primary goal is to make the tools more user-friendly for teaching and easier for children to understand and grasp." (T6)

This recognition—that even the most carefully planned methods may require ongoing iteration—points to a pedagogical impermanence, where the criteria of effectiveness must be continuously reimagined in response to VIC's evolving needs. Such fluidity departs from conventional educational paradigms, which often presume linear, quantifiable progression. Instead, learning here remains nonlinear, recursive, and at times resistant to closure. Teachers must function within a horizon of perpetual uncertainty, aware that even well-intentioned strategies can be undermined by children's unpredictable responses and sensory experiences. Ultimately, the teacher's professional identity, collaborative engagements, and ongoing design efforts are all enmeshed in a landscape where knowledge, authority, and outcome measures are permanently in flux.

5.3.4 Restrictiveness

The educational landscape for VIC is marked not only by pedagogical and cognitive complexities but also by the imposed limitations of broader systemic and cultural structures, which exert force upon both the child's developmental trajectory and the teacher's capacity to enact meaningful change. Within the framework of CHAT, these structures function as rules, constraints, and hierarchies that mediate human activity, shaping the very conditions of learning and participation. However, such mediation is not neutral; rather, it is laden with restrictiveness, a term that in this context gestures not only toward the material limitations of resources but also toward the institutional, ideological, and socio-historical barriers that delimit what is possible, thinkable, and actionable in the education of VIC.

The first manifestation of restrictiveness emerges in resource scarcity, a recurring theme in teachers' reflections,

> "Resource constraints, such as limited time for specialised training like sensory integration and a lack of systematic early education services, pose further barriers. Moreover, economic difficulties faced by institutions and families, whether it's a need for funding or parents' inability to afford specialised education, add to these challenges." (T4)

> "Internationally, many education experts emphasise introducing visually impaired children to various aids early, like Braille devices and dedicated computers. The goal is to transition from simple Braille writing to advanced internet operational skills. However, due to the lack of such equipment and trained teachers in our country, this method is challenging to implement. Similarly, we also lack specialised teachers to teach children orientation and mobility skills. Many parents and society generally believe that independent living skills are not a priority. They prefer to hire someone to care for their visually impaired children rather than teaching them independence. The situation and culture are different in every country, so a method that works well abroad might not necessarily work in China." (T8)

Inadequate funding, training, and institutional support do not operate merely as incidental obstacles; rather, they structure the very architecture of special education. The absence of resources does not simply denote a lack; rather, it determines the form and scope of pedagogical practice itself, restricting teachers' ability to innovate, adapt, and respond dynamically to children's needs. Within the CHAT framework, this speaks to a contradiction between the object of education (inclusive, individualized learning) and the systemic means available to realize it. The teacher, in this case, operates within a space of structural insufficiency, where the imperative to teach is always constrained by the enduring absence of adequate tools, funding, and institutional backing.

This material restrictiveness is compounded by societal misconceptions and prejudices, which impose further limitations on both educational possibility of VIC. The teachers describe the tensions faced by parents,

> "Some parents worry that although their children may have visual impairments, their intelligence and capabilities are no different from typical children. They are concerned that in special education schools, their children may lack proper competition and stimulation. On the other hand, if these children attend regular schools, they might face discrimination from other parents and children. Therefore, inclusive education is an ideal solution for VIC, but it also has its challenges in practice." (T2)

> "In some developed countries, doctors and teachers have their own specialties and complement each other. But domestically, many doctors don't value teachers' opinions, and some teachers don't even accept their peers. For instance, when parents ask teachers in schools for the blind if they should send their child there, they're told mainstream schools are better, leaving parents more confused. Special education is a unique field, but many people don't truly understand it. Some teachers give up upon hearing they have to teach blind students, thinking it's too challenging." (T8)

This articulation of parental anxiety highlights a structural double bind: whether placed in specialized or inclusive settings, children face restrictive logics—either exclusion from mainstream intellectual rigor or social marginalization within inclusive frameworks. What emerges here is a dialectic of inclusion and exclusion, where every available option is already compromised, already insufficient, revealing the deep-seated cultural hesitations surrounding disability and education. The teacher, caught in this dynamic, is not simply an educator but a mediator of systemic contradictions, attempting to navigate the restrictive frameworks imposed by societal norms while advocating for a more expansive, equitable vision of education.

Hierarchical biases regarding disabilities further exacerbate restrictiveness, as one teacher observes,

> "Some parents have higher expectations for their children and hope they can study among peers with better capabilities. This kind of 'hierarchical' thinking among parents is a problem we need to address. For instance, some parents think that children with low vision are superior to those who are completely blind, and those who are blind are superior to those with multiple disabilities. This mentality adds significant challenges to our educational and managerial tasks." (T1)

Such a hierarchy reflects a broader socio-cultural paradigm in which impairment is stratified, reinforcing a taxonomy of ability that affects access to resources, opportunities, and social validation. Children's worth is measured not by their individual capacities but by their proximity to normative embodiment. This metric, in turn, shapes educational policy, funding priorities, and even teacher expectations, circumscribing the very notion of success in VIC education.

Systemic restrictiveness also intersects with economic precarities, further entrenching exclusion:

> "Many parents cannot afford to give their children a better education due to financial pressures. If we could provide free education, including free accommodation, it would certainly attract more parents to send their children to study." (T3)

> "The public often only sees outstanding individuals from these groups, like those excelling in music or other areas, overlooking the majority who need care and help. This inequality in resource allocation is indeed problematic, fundamentally affecting the chance for these children to receive better education and services. So besides financial and resource issues, we also face societal challenges stemming from overly high expectations and value perceptions." (T8)

Economic constraint is not merely an external limitation but an active force that shapes participation itself, determining who can access specialized education and who is left without viable alternatives. Within the CHAT framework, this speaks to a contradiction that the ideal of universal accessibility collides with socio-economic structures that render such access conditional and unevenly distributed. Teachers, in this context, occupy a position of frustrated advocacy, fully aware of systemic inequities but constrained by the very institutions that maintain them. Ultimately, these systemic barriers—ranging from material scarcities and cultural prejudices to hierarchical biases and economic inequities—shape the educational landscape of VIC in deeply restrictive ways. For teachers, the challenge is not merely to work around these constraints, but to reimagine pedagogical practice so that it exposes and contests these limits.

5.3.5 Adaptation

Teaching within an environment of epistemic instability is to acknowledge that pedagogy is never fixed or complete but rather an ongoing process of negotiation, iteration, and adaptation. In the education of VIC, adaptation is not merely a pragmatic necessity; it is the very essence of teaching. It emerges as both an individual and collective response to the inherent contradictions within the learning activity system—contradictions between standardised curricula and the sensory particularities of VIC, between material limitations and pedagogical ingenuity, and between the permanence of knowledge and the fluidity of experiential learning. In this context, the teacher is not simply an instructor but a designer who continually modifies, revises, and redesigns pedagogical strategies in response to shifting VIC needs, available resources, and broader socio-material conditions.

A striking manifestation of this adaptive imperative is evident in the development and implementation of multisensory teaching methods. Teachers describe these approaches as follows,

> "We especially emphasise multisensory teaching methods. For instance, apart from traditional auditory learning, we also use touch as the main learning method. To deepen the children's impressions, we even transform the text into music for them to sing. In math classes, when teaching the concept of numbers from 1 to 10, for example, "What does 1 resemble? A pencil. So, what is a pencil?" We would hand them a pencil, allowing the child to touch the object physically." (T3)

> "The cognition of VIC is often based on their limited experiences. For instance, a child might judge an animal to be a horse because they've felt its mane or heard its neigh. This judgement isn't based on a singular experience—they might have ridden the horse, touched its entire body, and heard it neigh, thus it's a multisensory judgement. That single touch is just one source of information, while true cognition should be a combination of multisensory judgments. Even though they might not be able to outline a complete object, by touching different parts, hearing sounds, and other sensory experiences, they can piece together a comprehensive image of an object." (T7)

These statements underscore how adaptation in pedagogy is fundamentally a process of translation—of transposing concepts from one sensory modality to another in order to maximise accessibility and cognitive retention. Teaching here is not about fixing knowledge within a single representational form but rather about reconfiguring it through diverse sensory registers, ensuring that learning is not constrained by visual absence but rather facilitated through an alternative network of sensory pathways.

Adaptation in teaching extends beyond multisensory approaches to encompass pedagogical pacing and reinforcement. T7 reflects, "*if a child doesn't get a particular poem after one or two lessons, we try a different approach the next day or reduce it to teaching a single line*." Thus, adaptation operates through fragmentation—dividing knowledge into incremental, digestible units tailored to each child's cognitive tempo and sensory comprehension. This method challenges the standardised temporality of conventional education, which often privileges speed and linear progression over the recursive, cyclical nature of embodied learning. In this context, adaptation is not a compromise but a fundamental reorientation of pedagogical time, one that honours the individual rhythms of each child's engagement.

Material adaptation is equally indispensable in teaching, particularly in the design and selection of tactile learning resources. Teachers describe this process as follows,

> "To provide tactile experiences, we produce auxiliary teaching materials corresponding to the text content, such as using ultra-light clay, which is easy for children to touch, to simulate some objects. When studying the theme 'Beautiful Flowers' in May, teachers would pick some roadside, non-thorny flowers on their way to work. In class, children are allowed to gently touch and smell them, understanding that this is a flower and differentiating its parts like leaves, dried flowers, and wet flowers." (T3)

> "Some tools might be too heavy or inconvenient to place on a table during lessons, prompting us to consider alternative lightweight materials, like light clay, for redesigning or enhancing them." (T4)

> "We prefer making them ourselves. For instance, T1's class made some tactile teaching aids, such as toys made from milk powder cans that can be struck. We will look for appropriate tools and materials to make these learning materials based on our needs." (T6)

> "I hope for the creation of an information platform or website specifically designed for the blind, integrating auditory and tactile teaching resources. For instance, the site can collect auditory materials, tactile materials, and toys and books suitable for VIC." (T7)

These statements reveal an ontological shift in the function of teaching materials, where objects are not merely representations of concepts but direct facilitators of embodied cognition. Unlike traditional education—which privileges symbolic representation over direct interaction—learning in this context is grounded in material encounter: a tactile negotiation of the physical world. The classroom thus transforms from an abstract space into a lived environment navigable through touch, movement, and sound. This shift from abstraction to materiality, from symbol to experience, marks a radical pedagogical adaptation that foregrounds the body as an active site of knowledge production.

Nonetheless, even the most carefully designed adaptations must remain adaptable, subject to continuous evaluation, refinement, and transformation. Teachers reflect on this recursive process,

> "After testing new teaching methods or tools, we often make adjustments or optimisations. For example, we might initially design a simple version of a teaching tool. However, upon its actual use, we may find that modifications or refinements are needed to better meet educational requirements." (T3)

> "When initially setting a teaching method or tool, there might be an inaccurate estimation of the child's abilities and acceptance level. For instance, in language teaching, some children might not respond well to certain designated vocabulary, prompting us to adjust and choose simpler words. Originally, we might have wanted the child to learn a complex word like 'raisin', but if the child can't grasp it, I would switch to something simpler like 'medicine'." (T6)

Adaptation, therefore, is not a one-off modification but an iterative process in which each pedagogical tool or strategy undergoes continuous revision based on real-world classroom dynamics. This cyclical mode of refinement gestures toward an epistemic humility, wherein teachers acknowledge that no single method, no singular tool, can remain indefinitely effective—that all pedagogical interventions must remain provisional, flexible, and open to reconfiguration.

This insistence on adaptability is perhaps most acutely felt in the tensions between pre-existing educational structures and the realities of VIC, where teachers must continually negotiate between the expectations of standardised curricula and the idiosyncratic needs of their students. As one teacher articulates,

> "Some concepts, like clouds, are abstract and challenging to convey. Some content is particularly hard for visually impaired children to grasp, especially those closely associated with visual cues. But many of these contents might not be necessary for preschoolers to learn. The content we teach every year remains relatively consistent; the primary challenge lies in adjusting teaching methods and content according to

children's interests and abilities to make it more appealing and effective." (T2)

This statement reveals a fundamental contradiction within the educational system: while curriculum structures remain static, the conditions of learning are in constant flux, requiring teachers to mediate between the rigidity of institutional frameworks and the variability of child engagement. Adaptation, then, is not merely a pedagogical practice but a necessary survival strategy, one that allows teachers to function within and against the constraints of an educational paradigm that is often ill-equipped to accommodate difference. The adaptive labour reflects the ongoing transformation of the activity system itself, in which teachers, VIC, and material resources co-produce knowledge in ways that challenge traditional hierarchies. In this light, adaptation is not a concession to difficulty but an assertion of pedagogical possibility—an insistence that learning must be malleable, responsive, and attuned to the lived realities of those who navigate the world through non-visual modalities.

5.4 Design Implications

If we describe the learning process for VIC as a deliberate, painstaking extended enterprise of skillful design by the teacher, then the design strategies themselves emerge through iterative cycles of implementation, analysis, and modification. In these cycles, each pedagogically promising activity is continuously calibrated and aligned with others to test and refine hypotheses about the mechanisms that drive effective content teaching and learning. To clarify design strategies, enable broader dissemination of successful methods, and facilitate communication about both design practices and learning content, this section synthesises the primary design implications drawn from teachers' conceptualisations and enactments of design strategies for VIC.

Based on an analysis of observational and interview data, the findings highlight the iterative, context-dependent, and relational dimensions of pedagogical design in inclusive education. They indicate that teaching VIC requires moving away from rigid, predetermined methods toward more dynamic, adaptive, and multisensory approaches. Teachers, in this regard, serve not simply as facilitators of knowledge but as designers who continually modify, refine, and reimagine educational resources and experiences —responding to systemic constraints as well as the evolving cognitive, emotional, and sensory needs of their students. This section is organised around five core design implications (Table 5.3), each underscoring the inseparable bond between pedagogy and design and emphasising the necessity for situated, responsive, and co-constructed educational practices for VIC.

Table 5.3. Design implications that emerge from teachers' conceptualisation and implementation of design strategies.

Implications	Design Considerations
Adopting an individualised, needs-based design process	• Customising learning materials based on **individual sensory profiles**, rather than relying on standardised tools. • Ensuring tactile materials are **flexible and adaptable**, allowing teachers to modulate their use based on each child's cognitive and emotional variability.
Expanding multisensory design strategies	• Translating visual concepts into tactile and auditory modalities. • Mimicking real-world textures and contours in tactile materials, ensuring **material authenticity** in learning experiences.
Balancing standardisation with customisation	• Encouraging institutional investment in **teacher-driven** material development, recognising teachers' situated expertise. • Designing **scalable**, **modular learning materials**, allowing for real-time adaptation while reducing cognitive load on teachers.
Iterating learning materials for continuous refinement	• Designing **adaptable prototypes**, enabling teachers to modify, dismantle, or reconfigure materials while maintaining usability. • Prioritising **reusability**, **durability**, and **scalability** in material design to accommodate iterative classroom use.
Strengthening collaboration	• Ensuring learning materials are accessible across home and school settings, promoting **continuity and reinforcement**. • Collaborating with specialists (e.g., researchers, Braille experts) and leverage institutional networks for resource sharing.

5.4.1 Adopting an Individualised, Needs-based Design Process

One central implication of this individualised, needs-based approach is the necessity for material flexibility. Tactile learning tools must be reconceptualized not as static artifacts but as dynamic resources that can be modified, extended, and reinterpreted in response to a child's evolving needs. Accordingly, the design of tactile materials should prioritise modularity—enabling teachers to alter components, adjust textures, and restructure spatial configurations in ways that resonate with the child's sensory engagement. Modularity here operates not merely as a functional strategy but as an ontological reorientation: materials become fluid interlocutors in a tactile semiotics, where meaning emerges through iterative interaction rather than fixed representation. Crucially, this scaffolded progression—from elementary, sensorially legible forms to complex, abstract configurations—must be calibrated to the child's perceptual development, acknowledging the heterogenous ways tactile stimuli are encoded and interpreted across VIC.

Individualised design, thus conceived, is inherently iterative and improvisational, demanding teachers cultivate a pedagogical attunement to the child's affective rhythms and epistemic thresholds. This attunement manifests in real-time design: modulating pacing, reordering sequences, or reframing activities in response to somatic cues—resistance, withdrawal, or exploratory fervour. For instance, if a child exhibits frustration with a particular tactile activity, rather than persisting with a pre-planned exercise, the educator should pivot—introducing alternative textures, modifying the scale or orientation of objects, or integrating additional sensory cues (such as auditory reinforcements). Moreover, individualised design is not simply about adapting to a child's existing competencies but about expanding their sensorial and cognitive repertoire. This means exposing VIC to novel material encounters, introducing unexpected textures, patterns, or three-dimensional structures that encourage exploratory engagement. In doing so, educators foster tactile imagination, where children learn not merely to recognise but to conceptualize—mapping tactile experiences onto broader cognitive frameworks.

5.4.2 Expanding Multisensory Design Strategies

The fundamental design implications of a multisensory strategy lies in how learning materials themselves are conceptualised. Tactile materials—such as textured diagrams, raised words, and Braille—take on a dual function in this expanded framework. They are not mere substitutes for the absence of visual content but are integral to the creation of multi-layered, intersensorial experiences. The texture of an object, the weight of a material, or the pressure applied during tactile interaction all encode meanings that must be grasped and interpreted by the child. As such, tactile experiences do not only support cognitive development; they themselves form part of the epistemic process.

In expanding multisensory design strategies, materials must be developed with an eye toward both authenticity and functionality. For example, when representing abstract concepts, such as the notion of "growth" or "change," the material used to signify this must not simply be a mechanical replica of a visual form but an embodied metaphor—a textured surface that can be understood not only through its tactile properties but through the sensory relationships it establishes with the learner's body. Thus, the design of tactile materials must consider the gradients of texture (from smooth to rough), density (from light to heavy), and even temperature (warm versus cool) to create a richer, more nuanced interaction.

Equally, the role of sound in multisensory design extends far beyond the function of mere auditory instruction. It is through soundscapes—carefully constructed environments of layered auditory stimuli—that VIC are afforded access to otherwise abstract and intangible concepts. Sound mapping, where sounds are used to represent spatial relationships, or auditory cues that align with tactile interaction, create an enriched, cross-modal experience where each sensory input interacts with and deepens the meaning of the others. As a result, sound becomes a critical tool for the teacher to expand cognitive boundaries, offering alternative channels for processing and internalising knowledge.

5.4.3 Balancing Standardisation with Customisation

In the design of learning materials and pedagogical strategies for VIC, the tension between standardisation and customisation serves as a crucial axis around which the efficacy of learning experiences revolves. This dynamic, at first glance, appears to present a stark dichotomy: on one hand, the promise of standardised designs lies in the scalability, replicability, and ease of implementation across diverse educational contexts, while on the other, customisation offers the potential to tailor learning experiences to the highly individual needs, sensory profiles, and developmental trajectories of each child. The challenge, then, lies in reconciling these two imperatives: how to ensure that standardised systems of accessibility—such as Braille, tactile symbols, or audio-based technologies—serve as the foundational strategies for learning, while simultaneously allowing for customisation in ways that account for the individual sensory and cognitive landscapes of each child.

As mentioned in section 5.4.1, this can be achieved by adopting modular designs that allow teachers to adapt core materials to suit individual needs while still ensuring that all children have access to a shared, standardised base of knowledge. In this framework, core learning tools (such as Braille text or tactile graphics) would be supplemented with modular components that allow for adjustments in complexity, texture, or scale according to the child's specific abilities and preferences.

Such a model promotes flexible standardisation, in which the standard forms and structures of the material remain intact, but the delivery mechanisms are dynamic and responsive. For example, a standardised tactile map of a city could be supplemented with customisable textural gradients or removable components, allowing children to explore different aspects of the map at varying levels of detail. This modular flexibility enables the scaling of complexity, ensuring that students who are ready for more advanced material can access it, while those still learning the basics are not overwhelmed. Moreover, this approach allows teachers to adopt a proactive design stance—one that anticipates potential variability in the needs of their children, while providing them with tools and structures that can evolve over time. Rather than presuming a set of universal requirements for all children, it assumes that the classroom is a dynamic, fluid system in which materials must constantly evolve to maintain equity and accessibility.

5.4.4 Iterating Learning Materials for Continuous Refinement

The iterative process is not merely about tweaking materials or making minor adjustments, but rather about understanding the design as a fluid, recursive, and ongoing engagement with the lived realities of VIC and the pedagogical conditions in which they are situated. At its core, the act of refinement entails viewing materials not as isolated objects to be consumed by the child, but as sites of interaction, negotiation, and meaning-making. To iterate learning materials in a way that fosters meaningful learning for VIC is to engage in a process of constant recalibration—an ongoing dialogic interaction between the intentions of the designer, the responses of the children, and the feedback loops of the learning context itself.

The central implication of an iterative approach is the recognition that design is never final—it is, instead, a dynamic unfolding that continuously responds to the changing needs, challenges, and potentialities of the classroom. Learning materials for VIC, therefore, cannot be conceived as a set of instructions that simply need to be implemented. Rather, they must be treated as prototypes, subject to testing, feedback, and modification based on the child's engagement and the evolving pedagogical context. This fluidity allows for the adaptation of materials to a variety of learning conditions—be they cognitive, sensory, emotional, or social—that emerge as the teacher and child engage with the material over time.

An iterative model does not advocate for constant rejection of past designs, but instead focuses on the progressive improvement of existing materials through cycles of feedback and modification. These feedback loops operate on several levels. The teacher’s feedback is an immediate response to how materials function in real-time: whether the textures are legible, whether the auditory cues are distinct, or whether the materials foster engagement with the content. The child’s feedback, in turn, emerges not only through direct responses—such as verbal cues or physical manipulation of materials—but also through subtler forms of interaction, such as sustained attention, increased curiosity, or emotional engagement. Finally, external feedback from colleagues, specialists, or parents can offer additional perspectives on how learning materials are functioning, contributing to the broader community of practice that informs iterative refinement.

5.4.5 Strengthening Collaboration

Strengthening collaboration—across roles, disciplines, and institutions—becomes essential not only for the effective development of educational materials but also for the creation of an educational ecosystem in which resources, expertise, and insights are shared and collectively leveraged. The implications of strengthening collaboration in the design process are profound. Collaboration means more than just pooling resources; it necessitates the co-construction of meaning, the synthesis of multiple perspectives, and the acknowledgment of diverse forms of expertise. In this context, collaborative design does not simply distribute tasks but actively fosters a dynamic feedback loop, wherein the contributions of each participant enhance and refine the overall learning experience.

The strength of collaboration also lies in its ability to create inclusive communities of practice that transcend the boundaries of individual classrooms, institutions, and even geographical regions. When collaboration is deeply embedded in the educational fabric, it fosters a culture of shared responsibility for the success of VIC. In the broader context, these communities act as support networks, providing a space for reflection, mentorship, and collective problem-solving. When challenges arise—whether in terms of pedagogical strategies, material limitations, or institutional constraints—these communities offer a resilient infrastructure, wherein solutions can be devised collaboratively. Through such networks, teachers also gain access to professional development opportunities, deepening their understanding of best practices, emerging research, and innovative technologies that can enhance their teaching.

5.5 Chapter Summary

This chapter interrogates the learning activities through which teachers conceptualise and enact design strategies for VIC, positioning pedagogy as a dynamic, embodied, and relational act of meaning-making. At its core, the teacher's role transcends conventional instruction, emerging instead as that of a designer—one who designs tactile, auditory, and narrative architectures to mediate between the abstract objectives of curricula and the corporeal realities of non-visual cognition. The findings reveal that design for VIC is not a static endeavour but a recursive, improvisational process, shaped by the interplay of adaptive intentionality, contingent responsiveness, and systemic negotiation.

A range of factors that influenced teachers' design decisions were also presented at the levels of individual, team, community, social and institutional. Teachers conceptualise and implement design strategies for VIC through a dynamic, adaptive, and collaborative process. They navigate the balance between standardisation and customisation, iterating learning materials in response to ongoing feedback from children and colleagues. These design strategies are not solely focused on the materials themselves but are part of a broader, relational pedagogical framework that views teaching as a co-creative, feedback-driven process. The deeper interpretation of their relationships using CHAT is provided in the discussion chapter.

6. Materials as Protagonist

This chapter describes how materials is conceptualised and reflected in learning activities. Through a critical examination of how materials mediate interaction, meaning-making, and learning outcomes, this chapter will explore the intersection of design and perception, where materials are not simply tools for knowledge transmission but co-creators in the construction of learning itself.

This chapter is from an article under review:
Rong, A. & Hansopaheluwakan-Edward, N. (2025). Co-design as Pedagogy: Understanding Materiality, Designed Form and Learning Activity with/for Visually Impaired Children. *Co-design*.

6.1 Introduction

This chapter shifts focus from the processes and determinants of teachers' design decisions to the material themselves (artifacts in CHAT). The materiality of an educational environment extends far beyond its functional attributes; it plays a pivotal role in shaping not only the interaction with learning content but also the meanings constructed through the act of learning. This chapter addresses the **RQ2** posited in this thesis: "*How do materials shape learning activities for visually impaired children, and how do their properties influence interaction, meaning-making, and learning outcomes*?" I argue that in the intricate interaction between the material world and the learning process, materials are not passive objects but active protagonists in the educational narrative, especially when engaging with VIC. This chapter explores the dynamic role that materials play in the design of learning experiences, particularly focusing on how their properties—such as tactility, texture, weight, and flexibility—shape the sensory engagement of VIC. In this context, materials serve as a lens through which we examine the complexities of inclusion, agency, and participation within learning environments. Furthermore, I argue that materials do not merely function as mediums through which knowledge is conveyed; they act as integral agents in the pedagogical process, influencing not only how children interact with the curriculum but also the possibilities for their cognitive, emotional, and social development. Drawing on the richness of observation and interview data, and utilising thematic analysis techniques, I examined the moment-to-moment interactions between materials and children. In addition, I triangulated these findings with document data through content analysis, providing a comprehensive understanding of the role of materials in VIC education.

6.2 Qualities of Materials in Use

A property, in its classical formulation, denotes an intrinsic attribute inherent to an entity—a measurable, immutable characteristic of matter. A quality, by contrast, emerges as a phenomenological effect: the perceptible manifestation of properties as filtered through human cognition, cultural frameworks, or contextual interaction. Treating properties as wholly objective (e.g., the tensile strength of a Braille page) and qualities as merely subjective (e.g., the page's tactility as experienced by a visually impaired child) assumes a separation that does not hold: material features and perception are intertwined.

The issue is how we use language in different contexts. In scientific terms, properties are quantifiable aspects of matter (e.g., mass, conductivity, viscosity). In everyday use, qualities describe how these aspects are experienced (e.g., felt smoothness, how conductivity is encountered in practice). Treating the two as separate reinforces a misleading split between material features and human experience. In reality, they are intertwined: properties gain meaning as qualities in specific situations, and those experienced qualities, in turn, shape how we recognise and measure properties.

New materialist frameworks reject this either/or logic, proposing instead an and/and ontology wherein properties and qualities coexist as co-constitutive forces. Consider, for instance, the pedagogical implications: a textbook's weight (property) may engender fatigue (quality), while its textured binding (property) fosters tactile engagement (quality). To privilege one over the other—to fetishise quantifiable metrics or to romanticise experiential narratives—is to impoverish pedagogy. Thus, in what follows, I will illustrate why grasping the interplay between properties and qualities is essential for rethinking the material foundations of pedagogy.

6.2.1 Net

Stairwells, much like other architectural elements, are typically unnoticed in everyday spatial navigation, their presence assumed rather than scrutinised. However, in learning environments for VIC, such seemingly mundane features assume an active role in shaping movement, safety, and engagement. The stairwell, an architectural necessity, is transformed from a liminal space of passage into a site of careful negotiation, mediated by material intervention. The nylon netting suspended between the stairwell's first and second floors (Figure 6.1) exemplifies how mundane materials are reconstituted as protagonist within inclusive pedagogical spaces. Designed as a safety measure for VIC, the installation does more than protect. It functions as a tactile and spatial cue that supports how children navigate and make sense of their surroundings. To analyse its role, I consider both its properties (measurable material attributes) and its qualities (effects that arise through use in context).

The net's materiality embodies a dual function: materially, it acts as a barrier ensuring safety; pedagogically, it operates as an environmental cue that enhances spatial awareness. Its tensile structure (property), lightweight yet durable, creates a protective enclosure without instituting rigid constraints (quality). This duality reframes the stairwell from a zone of potential hazard to one of kinetic pedagogy, where balance, proprioception, and spatial reasoning are rehearsed through iterative touch. For VIC, the net's mesh grid (property) is not merely a structural safeguard but a tactile lexicon: fingers discern gaps and intersections, translating abstract concepts like "boundary" or "connection" into somatic syntax. Child D, for example, described his initial reaction to the nylon net in an interview, explaining that at first, its texture frightened him—he likened it to touching a snake—but after daily contact, he came to associate it with safety, noting, “I seem to have touched similar nets in shopping malls, and I felt safe.”

Figure 6.1. Coloured nylon netting hung between the first and first floor stairs.

This intervention is not merely a passive safeguard but an active participant in shaping embodied experience. Much like the writable white walls that transform vertical planes into interactive surfaces of expression, the netting serves as a semiotic material, a presence that is both felt and interpreted. Like the net's vivid colour (property) assumes pedagogical agency. While its primary function is non-visual, the colours serve as chromatic landmarks for children with residual sight, embedding colours into their cognitive maps. More than a functional safeguard, it thus becomes a pedagogical artifact—a material that both protects and instructs.

Table 6.1. The properties and qualities of the net.

Properties	**Qualities**
Colour (bright, vivid)	The netting's vibrant colours create a visual contrast that helps to delineate space. The colour serves not only to enhance visibility but also to evoke a sense of safety, as children instinctively perceive the boundary it establishes. For partially sighted children, chromatic contrast could become a navigational cue.
Texture (fine mesh)	The tactile texture of the nylon netting offers a subtle, yet significant sensory experience. As children brush against it, the texture becomes a point of contact that informs their spatial orientation. This subtle interaction is often overlooked, yet it plays a key role in how VIC understand and navigate their environment.
Weight (light, flexible)	The lightness of the netting allows it to sway gently with movement, which could create an awareness of dynamic spatial limits. Perceived as non-threatening, fostering exploratory engagement; its buoyant presence mitigates the rigidity of institutional architecture. VIC may engage with it as a semi-permanent feature in their environment, learning to use its presence as an aid to navigation.
Transparency (partially see-through)	The net's transparency invites a delicate balance between visibility and obscurity.It prevents children from accidentally falling while allowing them to maintain a perceptual connection to the wider environment.
Spatial Arrangement (positioned between floors)	The strategic positioning of the netting in the stairwell serves to break up the vertical expanse of the space, turning an otherwise unmarked boundary into an explicit, tactile intervention. This arrangement ensures that VIC are alerted to the boundaries between levels, while simultaneously offering them a framework through which they may better grasp the spatial flow of the environment. The netting acts as a physical and conceptual bridge, reinforcing the awareness of elevation and safe transition.
Colour (bright, vivid)	The netting's vibrant colours create a visual contrast that helps to delineate

	space. The colour serves not only to enhance visibility but also to evoke a sense of safety, as children instinctively perceive the boundary it establishes. For partially sighted children, chromatic contrast could become a navigational cue.

In the broader CHAT framework, the net is a mediating artifact, not a passive barrier. It shapes interaction by guiding hands and regulating movement, balancing safety with children's agency. In doing so, it turns the stairwell from a simple passage into a learning space where climbing builds autonomy, trust, safety, and environmental awareness.

6.2.2 Clay

The pedagogical potential of clay, particularly ultralight variants, resides in its capacity to transcend mere utility as a sculpting medium. Figure 6.2 and Figure 6.3 illustrate how this material becomes an active collaborator in the tactile and cognitive processes of VIC. Here, the act of shaping Arabic numerals—moulding ridges, curves, and edges—transforms abstract symbols into embodied, somatic knowledge. Unlike static Braille or printed text, clay's mutability invites iterative negotiation between concept and form, rendering mathematical literacy a dynamic, corporeal practice.

The material's properties—malleability, ultralight weight, and granular texture—are not inert traits but generative forces that co-constitute pedagogical qualities. Its malleability (property) allows for perpetual reconfiguration, enabling children to refine numerals through trial and error, a process that embeds kinetic memory into conceptual understanding (quality). The clay's ultralight composition (property) reduces physical effort, allowing longer use without fatigue (quality). Its granular texture (property) offers clear tactile contrast to smoother materials, improving sensory discrimination (quality). Even the clay's colour (property), though nonessential for VIC, highlights that the material does not rely on vision and keeps touch as the primary mode of interaction (quality).

Figure 6.2. VIC make Arabic numerals with ultralight clay.

Figure 6.3. A visually impaired child is touching the number 3 made of ultralight clay.

Children described the clay as “alive in [their] hands,” a sentiment echoing the material’s agential role. One child, while forming the numeral 3 (Figure 6.3), noted how the ridges “spoke back” under their fingertips, allowing them to “feel where the curve should bend.” Because clay is tensile and plastic (property), it both resists and yields. As a result, each numeral is shaped by feel: form is discovered through touch rather than imposed in advance (quality). This process aligns with Ingold’s (2013) idea of “correspondence,” where maker and material shape one another through ongoing tactile exchange.

Clay’s three-dimensionality reconfigures the pedagogical space: flat tables become topographies of possibility, and fingers, once passive receptors, emerge as agential explorers. The material’s ephemerality—its willingness to collapse and rebirth forms—mirrors the iterative nature of learning itself, where errors are not endpoints but portals to recalibration. This stands in stark contrast to rigid Braille texts, which prioritise fixity over flux. Here, clay’s protagonism lies in its capacity to dissolve the boundary between children and medium, rendering cognition a distributed, material act.

Table 6.2. The properties and qualities of the clay.

Properties	**Qualities**
Texture (soft, pliable)	The soft, pliable nature of clay is perhaps its most defining quality. For VIC, the smoothness and malleability of the clay allow for an intimate, hands-on learning experience. The texture becomes an extension of the child’s sensory exploration, inviting them to engage with the material through touch, shape, and form. The smoothness of the clay offers a contrasting tactile experience to more rigid, structured learning tools, allowing for the freedom to create without boundaries.
Weight (dense, ultralight)	The weight of the clay lends a sense of stability and presence to the activity. As children handle the clay, they experience its weight through tactile feedback, providing grounding and a tangible connection to the material world. This quality of weight invites a slower, more deliberate interaction, encouraging mindfulness in the act of creation. More importantly, it’s very safe.
Colour (varied, often vivid)	For VIC, colour may not be the primary defining feature of the material; instead, it is the texture and the act of shaping that becomes the focal point of the sensory experience. However, the teacher will still use different colours and tell the child

	that it is now the number three in yellow (Figure 6.3).
Responsiveness	As children press their fingers into the clay, the material responds by forming indentations or shaping according to their intent. This dynamic interaction between child and material offers immediate feedback, making the process of learning both interactive and self-reflective.
Flexibility	The flexibility of clay is a central attribute in fostering iterative learning. The ability to reshape and reform the clay allows children to experiment freely without fear of failure. They can return to the material again and again, altering it according to their needs or whims.

6.2.3 Tactile Books

The tactile book, a palimpsest of textures and intentions, emerges not as a mere repository of information but as a silent pedagogue in the hands of VIC. Figure 6.4 reveals two such artifacts: one crafted to teach spatial orientation through embossed images, the other to decode the Chinese phonetic alphabet via raised letters. These handmade volumes, stitched with care and pedagogical foresight, exemplify how materiality can transmute literacy into a multisensory dialogue. Far from passive carriers of content, they are kinetic landscapes where fingers trace meaning as eyes once scanned text, collapsing the divide between reader and read.

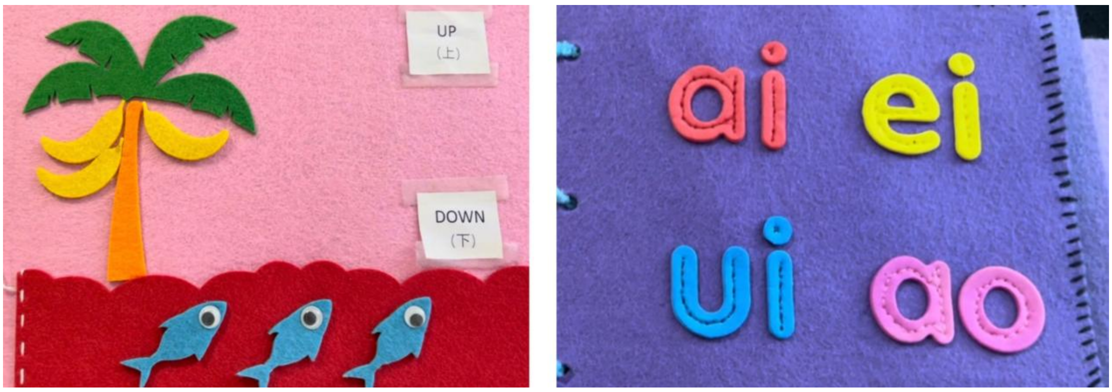

Figure 6.4. Volunteers handmade tactile books to help VIC learn orientation (left) and Chinese phonetic alphabet (right).

The books' material properties—textural diversity, volumetric relief, and artisanal construction—coalesce into a syntax of touch. Each page's texture (property)—whether grooved lines mimicking sea or letters—serves as a cartographic guide, translating abstract linguistic or spatial concepts into haptic legibility (quality). The deliberate juxtaposition of rough and smooth surfaces (property) does not merely differentiate symbols but curates a tactile narrative, where contrast becomes a pedagogical strategy for discrimination and recall (quality). The hand-bound nature of these books (property), with their uneven edges and variable tension, imbues them with an organic unpredictability that resists the sterility of mass-produced tools, fostering a sense of intimacy and ownership in the child (quality). Children likened the orientation book to "walking with [their] fingers," describing how the raised pathways allowed them to "see images without eyes." A teacher noticed that the children often lingered on the pages of the book, not just decoding, but "conversing" with textures, enjoying rubbing their fingers repeatedly against the different materials.

Table 6.3. The properties and qualities of the tactile books.

Properties	**Qualities**
Texture (rough, smooth, raised)	Translates abstract concepts into navigable tactile landscapes. The act of running fingers across the textured images and words connects the child to the book, turning the page into a dynamic interface for learning.
Size (large, easy to handle)	The size of the tactile book is often designed to be large enough to facilitate easy manipulation, ensuring that children can comfortably handle and explore the pages. This larger scale serves to amplify the tactile experience, making it easier to trace the raised images. It also creates a sense of tactile space, inviting children to engage more fully with the material.
Material Construction (durable, hand-stitched, uneven)	Tactile books are often constructed from durable materials to ensure they can withstand frequent handling. This durability also provides a sense of security and stability, as children can confidently interact with the book without the fear of damaging it. However, it is still easily damaged because it is hand-stitched.
Interactivity (flippable, manipulable)	he tactile book's interactivity, defined as its ability to be flipped, turned, and physically manipulated, adds a layer of engagement that extends beyond simple reading. This quality invites children to actively partake in the unfolding of the narrative or exploration of concepts, thereby integrating the act of turning pages into the learning process.
Colour (easily distinguishable)	While the colour requirements are less exacting for VIC, the utilisation of large blocks of colour and colours with a high degree of colour contrast is beneficial for both teacher and child in distinguishing between different objects.

These tactile books function as boundary objects, mediating between institutional curricula and embodied cognition. The portability of the tactile book (property) allows it to be used on a desk, a lap, or the floor, supporting structured learning in many settings (quality). Its fragility (property), due to handmade construction, encourages careful handling and awareness that materials can wear or change (quality). Here, the tactile book transcends its role as object; it becomes a collaborator in the silent, learning experiences of making the world legible, one ridge at a time.

6.2.4 Perkins Brailler

The Perkins Brailler is a practical, durable tool that remains central to accessible literacy. It is both material and material-maker. Figure 6.5 captures its presence: a metal-clad apparatus, its surfaces worn smooth by a decade of diligent keystrokes, now wielded by university volunteers to create Braille texts for Chinese language class. Unlike clay or nets, which invite direct tactile exploration, the Brailler works indirectly through the hands of teachers to convert text into raised dots. In doing so, it not only makes pages but also supports the infrastructure of inclusive teaching by enabling timely, consistent production of accessible materials.

Figure 6.5. University student volunteers are using Brailler to create written materials for Chinese language classes for VIC.

The cast-iron frame (property) is plain and durable, prioritising longevity over appearance (quality). This sturdy build supports decades of use and signals institutional reliability. The absence of extraneous features (property)—no digital interfaces, no modular attachments—renders it a paragon of focused functionality, demanding mastery through repetition rather than intuitive affordances (quality). Teachers report consistent, repeatable output; the simple mechanics let them keep a steady rhythm in Braille transcription even as digital tools become more common.

The machine's tactile feedback (property)—a resonant click with each embossed dot—transforms transcription into a somatic dialogue. This auditory-tactile synchronicity (quality) allows VIC to "hear the text taking shape," as one volunteer described, rendering the act of Braille creation both performative and meditative. The resultant Braille pages, with their uniform indentations (property), become not mere carriers of information but tactile artifacts of pedagogical intentionality, their precision a material echo of the Brailler's unwavering mechanics (quality). In this interplay of metal and meaning, the Brailler transcends its role as mere tool. It becomes an archival object, its materiality encoding the history of tactile pedagogy—each keystroke a negotiation between teacher, machine, text and learning activity.

Table 6.4. The properties and qualities of the Perkins Brailler.

Properties	Qualities
Material Composition (metal, robust)	The Perkins Brailler is constructed from durable metal, which contributes to its weight and stability. This materiality ensures that the Brailler can withstand the rigours of daily use, retaining its functionality over extended periods. For teachers, the sturdy material facilitates easy operation without the concern of breakdowns or wear.
Design (unfurnished, utilitarian)	The Brailler's simple, utilitarian design reflects its primary function: to produce Braille text. The lack of extraneous decoration or ornamentation ensures that the focus remains on practicality and efficiency. Its minimalism speaks to a design philosophy that prioritises accessibility, ease of use, and functionality, which in turn promotes its seamless integration into daily classroom routines.
Mechanism (manual,	The simplicity of the mechanical system ensures that the device is easy to maintain, and it allows for consistent, reliable use without the complications that may arise

mechanical)	with more complex electronic devices.
Size (portable)	The compact size of the Perkins Brailler makes it a practical tool for classroom use. It is portable enough to be moved around as needed, allowing teachers to use it in a variety of contexts and settings.
Shared (easy operated)	The Perkins Brailler is primarily used by teachers, who act as the mediators of Braille literacy. The shared nature of the Brailler does not detract from its effectiveness; rather, it reinforces the collaborative nature of the learning process, where the teacher's role is integral to shaping children's engagement with Braille.
Functionality (flexible, meets daily needs)	Whether used to transcribe short notes or complete curriculum materials, the Brailler's functionality aligns closely with the routine requirements of the classroom. Its ease of operation and reliable output ensure that it can support a wide range of tasks, from lesson preparation to VIC work, without the complexities of modern, more delicate technologies.

6.2.5 Reflections on Qualities and Properties

Size, weight, design, texture, colour, and function shape how materials work within an activity. Their effects are specific to each material and remain relatively stable, even as contexts change. For example, the nylon net began as a safety device but now acts as a mediating artefact that guides movement and supports spatial learning. Its tension and colour contrast make stairwells easier to navigate and safer to use. Clay, by contrast, is malleable; unlike the fixed form of embossed Braille, it supports trial, revision, and exploration. Tactile books use their material qualities to structure learning, influencing cognitive, social, and emotional engagement; they function as active teaching aids rather than passive tools. The Perkins Brailler illustrates how durable, focused design meets pedagogical needs by enabling reliable production of accessible text.

Understanding these dynamics means looking beyond simple utility. Following Ingold (2011), knowledge grows through skilled attunement to environmental cues—responding to changes without breaking the flow of action. From this view, choosing and arranging materials is a pedagogical decision. Noticing how material qualities shape activity helps identify which parts of a lesson can be changed. Because people actively shape their environments, and materials can participate in co-creation, a holistic view is needed. This perspective lets teachers adapt what they can (e.g., material selection or configuration) even when other constraints remain, distributing agency across learners, teachers, and materials.

6.3 The Children-Materials Relationship

It is now widely acknowledged that human existence and social life are contingent upon material objects and are intricately intertwined with them; as Hodder (2014, p.19) states, “humans and things are relationally produced.” However, materials are inherently finite. They are unstable both in their own right and in their interactions with other entities. They undergo transformations in accordance with natural cycles, ranging from daily rhythms to decadal and millennial shifts, and through processes of deterioration and depletion. Materials possess qualities and affordances that endure across different contexts, generating both opportunities and limitations for learning activity. This, in turn, gives rise to unforeseen and unintended consequences. Moreover, it is precisely due to our profound entanglement with materials that we are compelled to adapt to these changes in the material world.

Developing an appreciation for the material qualities is merely the beginning. Material flows and streams of consciousness intersect in countless ways, and the junctures of these connections are mediated and molded by the materiality that is embedded within learning activities. Ingold (2013) introduces the concept of *transducers* (p.102), which he uses to describe things that convert thought into action through doing. This idea adds depth to our understanding of how materials influence the course of activity, mediating between objects and thought. Nonetheless, this perspective predominantly focuses our attention on the actions of an individual working with a single tool. In this section, I aim to shift our focus from the individual to the collective, and to examine learning activities from a more expansive vantage point.

6.3.1 Material Engagement and Sensory Interaction

The dynamic interplay between material properties and the tactile senses of children is a primary conduit through which knowledge is constructed, especially when sight does not serve as the primary avenue of exploration. As the interviews reveal, these sensory engagements are not merely reactive responses but embodied dialogues between the child and the material world.

> "One time T5 took a tactile book with a bear in it. I just love bears." (A)
>
> "Do you know who my best friend is? His name is ... Teacher Anqi, let me introduce you to my bear (a 5cm crystal bear that I take out and carry with me at all times of the day) and my snowflake best friend." (B)
>
> "I have many watches at home, one is worn on the wrist. My mum bought me one, that one has a voice chime. I like to touch the little particles." (D)
>
> "I like to touch it too (When child D responds that he likes to touch the small particles, she indicates that she likes it too)." (C)

Children like child A express profound joy in engaging with tactile materials, particularly tactile books. Her fondness for books with animal motifs—like a tactile book featuring a bear—illustrates the capacity of materials to evoke deep emotional connections. Child B also demonstrates the way in which materials shape learning through sensory interaction. His attachment to a small crystal bear, which he carries with him throughout the day, reveals the emotional significance materials can carry. This sense of attachment highlights the reciprocal relationship between the child and material, where the object becomes a tool for emotional and sensory exploration, facilitating both comfort and learning. Moreover, the materiality of everyday objects, such as child D's fascination with a watch with sound or C and D's preference for small, tactile particles, offers further insight into how children selectively engage with materials based on their sensory experiences.

Also, Child B demonstrates engagement shaped by the texture and interaction possibilities of materials. Child B's fondness for a talking watch, which provides both tactile and auditory feedback, highlights the multimodal engagement that some materials invite. His description of the watch—"*I like the watch that tells you what time it is, like 9 o'clock and you flick the switch and it says 9 o'clock*"—underscores how the combination of sound and touch can create an enriching sensory experience that can be deeply satisfying for visually impaired children.

These vignettes collectively affirm that sensory interaction is neither neutral nor static. It is a palimpsest of encounters, where each touch inscribes new meanings onto materials, just as materials reciprocally sculpt cognitive and emotional landscapes. For VIC, this sensory lexicon is not compensatory but constitutive, a testament to how blindness reconfigures, rather than diminishes, epistemic possibility.

6.3.2 Material Preferences and Emotional Responses

The interplay between material preferences and emotional responses in VIC unfolds as a silent symphony of tactile affinities and aversions, where materials emerge not as inert substrates but as resonant companions in the choreography of learning. Child A's declaration, "I just love bears," transcends mere preference; it signals a convergence of material texture and emotional resonance. At the same time, children have clear expressions of their preferences, such as Child C, "*Ms Anqi, are you afraid of snakes? I wouldn't be afraid to touch a snake.*" And child D, "*Yes. But I can't visualise it. I like to touch small animals! Do you know what's my favourite animal's name? Butterflies, and penguins*!" These preferences, far from arbitrary, are inscribed within a dialectic of sensory allure and existential resonance—a negotiation between the tangible immediacy of matter and the intangible weight of memory, identity, and comfort.

The relationship between children and materials is not solely one of positive engagement. Child D's aversion to the texture of nets (Figure 6.1) is another example of how material properties can challenge interaction and inhibit learning. In contrast to the enjoyment that tactile materials like books or toys bring, the texture of a net becomes a sensory barrier, one that can cause discomfort and hesitation. This reaction underscores the importance of considering both the tactile qualities that foster engagement and those that may disrupt it. D's reluctance to touch nets due to their texture—described as "ticklish" or "itchy"—highlights how materiality can affect a child's willingness to interact.

> "I'm afraid of touching puppies. I'm not afraid of touching a snake. (After B asked the piggy's question she added the reason why D was afraid of touching the net) Teacher, when D touches the net, that net tickles his feet and he also feels that it is so itchy that he doesn't want to play with it!" (C)
>
> "Nets. Fear of touching the net, didn't we have that safety net next to us when we went up and down the stairs? Just fear of touching the net, everything that's netted doesn't work. And soft, sticky things. (Agree with B) Yes, I'm afraid to touch the net. I'm afraid to touch the resin net, but I'm not afraid to touch the wire net." (D)

However, material preferences are not static monoliths but fluid negotiations, shaped by the alchemy of time and trust. Child D's initial revulsion toward the stairwell net—its mesh likened to a snake's skin—gives way, through daily encounter, to a grudging alliance. "I felt safe," he later admits, invoking memories of similar nets in shopping malls. This metamorphosis from aversion to acceptance mirrors what could described as the "fold" of experience—a process where repeated engagement with a material's properties (texture, flexibility) gradually rewires affective responses. The net, once a source of tactile dissonance, becomes a mnemonic scaffold, its qualities reframed through the slow accrual of embodied familiarity.

6.3.3 Material Affordances and Learning Outcomes

The materials that VIC engage with offer far more than mere sensory experiences; they afford particular modes of interaction that significantly shape learning outcomes. These affordances are not merely passive attributes of the materials themselves but become active participants in the process of learning, enabling children to negotiate meaning, enhance cognitive abilities, and foster a deeper sense of self-efficacy. As revealed in the interviews, the sensory properties of the materials—whether tactile books, clay, or even everyday objects—interact with the child's individual capabilities, shaping their learning trajectories in ways that are both subtle and profound.

Child A's admission that Braille is "*so hard to write and touch-read*" lays bare the Perkins Brailler's dual affordance: its mechanical precision demands discipline, embedding resilience into the act of literacy. Here, the Brailler's affordance is not merely functional (producing Braille text) but existential: it inscribes the child into a lineage of tactile literacy, its unyielding frame a testament to the labour of inclusion. Yet, this very rigidity—its resistance to ephemeral whims—also alienates. Child A's distaste for touch-reading lessons, despite her Braille proficiency, reveals the fissure between institutional affordances (structured literacy) and learning experiences (discomfort with tactile abstraction).

The humble school bag zip, cited by child D as his "hardest problem." The zip's metallic teeth, designed to afford security, morph into a labyrinth of resistance for small, unsteady hands. Child E's role in zipping D's bag, meanwhile, transmutes this affordance into a social covenant: the zip becomes a mediator of camaraderie, its functionality entwined with relational care. Also, Watches adorned with voice chimes, favoured by Child B and D, illustrate how affordances transcend utility to become kinetic metaphors. This affordance, though incidental to the watch's design, becomes a pedagogical windfall: a tool for sensory discrimination, rhythm perception, and even mathematical abstraction. The ocean ball pool, cited by child D as a "moment of good times," transforms kinetic play into spatial literacy, its buoyant spheres mapping proprioceptive boundaries.

Ultimately, these examples underscore how material affordances shape learning outcomes not only through direct interaction but through the child's evolving relationship with the material—materials are integral not just to knowledge acquisition but to the emotional and social dimensions of learning, shaping the child's educational experience in ways that are both profound and transformative. In this interplay, learning outcomes emerge not as linear achievements but as rhizomatic growths—tactile literacies, problem-solving resilience, social reciprocity—rooted in the child's negotiation with material possibilities.

6.3.4 Social and Collaborative Learning through Materials

The interviews illuminate a chorus of voices, each child's interaction with materials subtly refracted through the presence of peers. Consider child A, who, in the interview, offers a snack to her friend child C, proclaiming, "*Thank you C, I wouldn't have been so happy without you.*" Here, the material act of sharing food—prompted by the interview's structure and the teacher's provision of rewards—becomes a conduit for gratitude, binding the solitary triumph of learning into a communal gesture. Such collaborative currents ripple further in the children's recounting of triumphs and tensions. Child C proudly declares, "*I can wash dishes and spoons well*," before weaving child A and child E into her narrative as "good students" whose presence amplifies her joy. The materiality of the classroom—its dishes, its spoons—serves as a stage for collective achievement, where individual skill is magnified through mutual recognition. Yet this harmony is not untroubled. Child A's grievance—"*I'm not happy that you (child C) pushed me and you turned the ocean ball pool over*"—reveals how materials like the ocean ball pool, intended for play, become arenas of contestation. The buoyant spheres, once vessels of "good times" for child D, morph into agents of discord, their affordances reshaped by the push and pull of social dynamics. Here, materials do not dictate collaboration but mediate it, their qualities—softness, mobility—eliciting both unity and rupture. Child A recounts a tender vignette,

> "One day we went out to play and when we came back, the other children were asleep and so was D. They were sitting next to each other and E let D lie on his legs and sleep!" (A)

Though no tangible object anchors this scene, the school bus—a material space—frames their intimacy, its seats and rhythms fostering a quiet solidarity. Yet this collaboration is not seamless; it is a fraught negotiation, laced with the children's divergent impulses. Child C bristles at her peers' noise—"I don't like you guys either. You're too noisy!"—a sentiment born from the cacophony of collective play, perhaps amid the tables and chairs or the clang of shared tools. Materials can intensify friction as well as support coordination; they both enable and strain cooperation. Thus, collaborative learning is a shifting balance rather than a stable harmony. The classroom functions as a site of co-creation in which materials and children act together, underscoring the social nature of learning.

6.3.5 Material Mediation in Learning Activities

Material mediation, in this context, refers to the process by which physical objects—be they tactile books, auditory devices, or everyday artifacts—actively participate in the construction of knowledge and the facilitation of skill development. Figure 6.6, a teaching guide for materials and activities used by teachers, illustrates how materials are carefully curated to mediate learning experiences. The teaching materials emphasise that it is best to begin the process of moving up from physical objects to abstract representations slowly, pairing actual objects with more abstract materials, and knowing that the child demonstrates that he has a clear understanding of abstraction. For example, before wiping the child's face, let him touch the towel (physical cue), then before you start wiping his face, touch the part you want to wipe, such as touching his mouth (touch cue), and also use clear, concise, and consistent phrases as oral cues.

Figure 6.6. Teaching guide for materials and activities used by teachers.

Materials in the learning activities of VIC are not mere adjuncts to pedagogy but integral mediators that shape cognitive, sensory, social, and emotional development:

> "I have a good friend at home, his name is Toy Fish, soft and hard kind of material." (B)

> "Ms Anqi, that's me on this cover, it's smooth, you touch it. This one is me playing the piano, it's a picture of me at school." (D)

> "I like ponies. Teacher, I also have a favourite best friend called Bear, she is also a little sister and her nickname is Bear. She is my only good friend, a doll!" (C)

> "C is very good at self-care, as well as fine motor skills. She has come up with a very good method that the other children have not thought of. She has small hands and she is short, the smallest child in the class! She wanted to put the white cane into her school bag, but she couldn't reach it when it was on her back, so she thought of a way to pull the bag up a little bit so she could put the white cane into it. So I think C's ability to solve problems by herself is wonderful!" (A)

> "I like music class because it has musical instruments and I like African drums!" (E)

From the disciplined rigour of the Braille to the imaginative expanse of toys, from the auditory cues of African drums to the social negotiations around white cane, each material artifact plays a pivotal role in the educational narrative. These materials, in their silent eloquence, speak to the profound entanglement of matter and meaning, reminding us that learning is not an abstract endeavour but a deeply embodied, relational act. As we design and select materials for learning activity, we must attune ourselves to their mediating potentials, crafting environments where every touch, every sound, every interaction becomes a thread in the rich tapestry of learning.

6.3.6 The role of teachers in mediating material interactions

In the silent symphony of VIC education, where materials pulse with latent potential, the teacher emerges as alchemist—transmuting the inert into the dynamic, the physical into the profound. Through curation, adaptation, facilitation, and advocacy, they mediate the child's dialogue with the world, rendering each touch and sound a thread in the fabric of learning. We can see from the children's interactions with the materials that the teacher acts as curator to craft multisensory ecologies; adaptor to tailor materials to individual learning journeys; facilitator to nurture social and emotional resonance; advocate to shape inclusive materialities. For example, the interview data reveal that teachers are mindful in introducing materials that align with the children's developmental stages, as seen in the learning activities designed to refine fine motor skills, like those detailed in C1 through C5 of the IEP goals (Table 6.5). Through such activities, children gradually learn to engage with materials such as geometric blocks, beads, and Braille tools, each item carefully chosen to meet specific educational needs, ranging from the development of grip strength to the understanding of spatial concepts.

Table 6.5. Bethel China children's learning objectives examples (July, 2023).

Code	Task	IEP (individualised education plan) Objectives

C1	Fine	One-handed grip, geometric block drop box
	Self-Care	Putting on socks, eating with a hand-assisted grip on a spoon in the behind-the-back position (lasts for one meal)
	Language	Comprehension: one-step instructions (clap hands, stomp feet, touch head), Expression: accurately expressing own needs, increasing motivation to communicate
	Orientation	AMD usage (correct grip, forward motion), familiarity with cue objects: glass walls, door frames, tactile boards, height sticker, washbasins, route: classroom to toilets
	Cognition	Body parts (eyes, nose, mouth, ears), bells/balls
	Rough	Equipment practice in the sensory classroom
C2	Fine	Hands coordinated, fishing line beads (1cm, hole 0.3cm)
	Self-Care	Putting on socks and shoes
	Language	Comprehension: two-step instructions (10 words), understand simple illustrated books and be able to answer questions based on the content, Expression: accurately express own needs, retelling illustrated books
	Orientation	Practice walking along, familiarity with cue objects: glass walls, door frames, height sticker, cupboards, route: classroom to sensory classroom; practice walking up and down stairs independently
	Cognition	Body parts (wrists, elbows, waist, review knees), differentiate between left and right, compare and contrast concepts: size, lightness and weight
	Rough	Equipment practice in the sensory classroom
C3	Fine	Hands coordinated, fishing line beads (1cm, hole 0.2cm), differentiated size, set of cups
	Self-Care	Distinguish between front and back of clothes
	Language	Comprehension: two-step instructions (10 words), simple illustrated books, Expression: accurately expressing own needs, retelling illustrated books, vocabulary building
	Orientation	Use of a white cane (correct grip, gliding), familiarity with clue objects: water grates, kerb, parapets, stone walls, glass doors, iron posts, route: school to supermarket
	Cognition	Body parts (wrists, elbows, waist, review knees), differentiate between left and right, compare and contrast concepts: size, lightness and weight
	Rough	Equipment practice in the sensory classroom
C4	Fine	Hands coordinated, block sets of columns
	Self-Care	Putting on socks, eating with a hand-assisted grip on a spoon in the behind-the-back position (lasts for one meal)
	Language	Comprehension: one-step instruction (3 words), Expression: to be/not to be, increased motivation to communicate
	Orientation	Hearing aid usage, familiarity with cue objects: glass wall, tactile board, height sticker, small platform, washbasins, screen, route: classroom to height sticker; practice going up and down stairs independently
	Cognition	Spatial orientation awareness: up, down, left, right, toothbrush/toothpaste

	Rough	Equipment practice in the sensory classroom
C5	Fine	Hands coordinated, fishing line beads (1cm, hole 0.3cm)
	Self-Care	Wear a coat and zip it up.
	Language	Comprehension: one-step instruction (5 words), Expression: accurately express own needs, to be/not to be, taking turns in answering practice
	Orientation	Use of a white cane (correct grip, gliding), familiarity with clue objects: glass walls, door frames, tactile boards, height sticker, small platform, washbasins, stairwells, shoe cupboards, route: classrooms to ground floor shoe cupboards
	Cognition	Body parts (wrists, elbows, waist, shoulders), concepts: size, lightness and weight
	Rough	Equipment practice in the sensory classroom

6.4 Chapter Summary

In this chapter, the discourse transcends the utilitarian veneer of educational artifacts, recasting materials as vibrant protagonists within inclusive pedagogy, particularly for VIC. It navigates the intricate dialectic between the tangible properties of materials—texture, weight, flexibility—and the emergent qualities they evoke through sensory communion, positing that such interplay is foundational to crafting inclusive learning ecologies. Understanding materiality is about gaining a thorough awareness of the cognition of VIC. Experienced teachers can expeditiously ascertain the suitability of material for use with VIC; however, inexperienced individuals frequently encounter challenges in identifying the appropriate point of departure. Through a meticulous exploration of artifacts like the nylon net, ultralight clay, tactile books, and the Perkins Brailler, the chapter unveils how these materials, far from inert auxiliaries, become conduits for sensory engagement, cognitive enrichment, and social interplay, each tailored to the perceptual exigencies of VIC. What is more, following the histories of materials and noting how their material qualities change or persist over time, gives us insight into the processes of change in learning activities.

The results foreground the agency of children in their material encounters, where tactile preferences and emotional resonances weave a relational fabric that shapes learning trajectories. This dynamic is amplified by the mediating presence of teachers, who curate and modulate these interactions, ensuring that each material engagement aligns with individual developmental arcs. The chapter thus contends that materials, when judiciously integrated, transcend their ostensible functions to co-author an educational narrative—one that is embodied, relational, and transformative. The findings outlined in this chapter are advanced in the discussion chapter 9.

7. Designer as Negotiator

This chapter positions the designer as a negotiator who navigates intersecting activity systems—teachers' pedagogical frameworks, VIC's experiential knowledge, and material possibilities. It introduces that rather than designing learning materials directly, designers can help teachers identify problems with the design process and how to solve them.

This chapter is from the articles under review:
Rong, A., Xu, J., Gao, H., Lin, Z., & Wei, W. (2024). Experience as it is experienced: Effectiveness of Sensory Integration Based Multi-sensory Books Design Centered on the Experience of Visually Impaired Students. International Journal of Disability Development and Education.
Rong, A. & Hansopaheluwakan-Edward, N. (2025). Co-design as Pedagogy: Understanding Materiality, Designed Form and Learning Activity with/for Visually Impaired Children. *Co-design*.
Rong, A. & Hansopaheluwakan-Edward, N. (2025). Who Designs, Who Teaches, Who Knows? Negotiating Co-Creation with Visually Impaired Children. In *International Association of Societies of Design Research IASDR* 2025.

7.1 Introduction

Change within any system is rarely straightforward, and it is not accomplished merely through the acquisition of new ideas. It demands collective ingenuity from teachers and designers alike, who must collaboratively interrogate how co-design processes might most effectively realise pedagogical objectives within specific contextual constraints. While preceding chapters have examined the institutional frameworks of educational systems, this chapter shifts focus to the designer's role as a mediator within (co-) design, specifically in negotiating power dynamics, roles and relationships between teachers, VIC and materials. It contributed primarily to **RQ3**: "*How do designers negotiate the roles, relationships, and power dynamics between materials, teachers, and visually impaired children during the co-design*?" Through a synthesis of expert interviews (list of interview questions can be found in Appendix D) and prototyping design, the chapter elucidates the discursive and material strategies designers employ to recalibrate authority, foster equitable collaboration, and foreground the sensory and cognitive needs of VIC. Successful co-design required designers to destabilise hierarchies, embrace ambiguity, and treat materials as dynamic collaborators. These findings underscore the need for relational literacy in design practice, where negotiation is not a hurdle but the core of creativity.

7.2 Roles, Power, and Relationships

Using thematic analysis guided by Third Generation CHAT, I identified six key themes that illuminate how designers negotiate roles, relationships, and power dynamics in co-design with materials, teachers, and VIC (Table 7.1). Designers lead but adjust based on teachers' expertise and children's input, while materials both enable and constrain outcomes. Collaboration and external contexts further shape these negotiations, aligning designs with accessibility goals. This preliminary analysis would be refined with the full dataset, but it provides a robust framework for understanding co-design dynamics in this context.

Table 7.1. Themes and sub-themes from analysing the data in the interviews with experts.

Themes	**Sub-themes**
Reframing Roles and Expertise	· Defining designers' role in co-design · Redefinition of hierarchy · Children's active participation in shaping design
Power Dynamics	· Designers' authority in decision-making · Teachers' influence through expertise · Materials as agents of power
Materials Mediation	· Materials as tools for accessibility · Collaborative selection of materials · Constraints imposed by material properties
Collaboration and Communication	· Interdisciplinary teamwork between designers and teachers · Negotiation through iterative design processes
Accessibility and Inclusion	· Designing for tactile recognition · Balancing complexity and usability for VIC · Addressing diverse needs of VIC
Contextual Influences	· Institutional policies shaping co-design · Technological advancements as enablers · Community expectations and norms

7.2.1 Reframing Roles and Expertise

In co-design for VIC, designers do far more than supply visual flair or technical fixes. Multiple experts describe them as mediators, problem-solvers, and even social advocates, whose influence spans from conceptual planning to classroom implementation. Designers repeatedly take on a translation function between distinct spheres of design knowledge—they must synthesise educational content, teachers' insights, and the practicalities of sensory perception. Moreover, digital and mechanical production demands specialised knowledge, which designers wield to communicate effectively with printing companies, administrators, and parents unfamiliar with the technology. As one expert notes:

> "It is not just a design issue, but a major topic related to social justice and inclusion... I began to think: how can graphic information be accessed... how can we design these graphics in such a way that they are cognitively appropriate...?" (E2)

Designers frequently find themselves negotiating among sometimes competing imperatives—such as a teacher's desire for immediate, child-specific materials versus the financial constraints of publishers. This dynamic arises because only a handful of companies can mass-produce tactile or large-print materials in China (E1). Thus, while teachers might want highly customised content, large printing firms work within stricter parameters (e.g., minimal "set-up time," standardised templates). As E1 explains,

> "Designing and producing tactile books is labour-intensive, time-consuming and costly. According to the experience in Finland and Russia, professional designers can design and produce at most one or two touch books in a month, and beginners - one in half a year. However, when skilled, everyone can become a professional and can produce a five-page, ten-sided tactile book in one or two days."

A recurring motif in the interviews is the subtle redefinition of hierarchy within design teams. As illustrated by references to teacher-designer collaborations:

> "Teachers often create new content tailored to each child's context… they adjust materials based on reading ability or age group. But they also consult with editors or designers to refine tactile clarity" (E1).

Thus, rather than a unidirectional flow of instructions from teachers to designers (or vice versa), a co-regulatory model emerges. Teachers articulate the curricular intention (why a tactile book or large-print text is necessary), and designers respond with possible technical or aesthetic methods. Yet, as some experts caution, the designer retains significant authority where specialised production is concerned—especially in advanced technologies or training support:

> "Teachers need more training and resource support in using these learning materials. They need to understand not only how to use these aids, but also how to adapt and optimise them to the individual needs of their students. By strengthening teachers' professional training and enhancing their competence in the use of assistive technologies and curriculum materials, they can better support the learning of visually impaired students." (E2)

Children's participation goes beyond identifying errors or requesting textures: some even shape thematic or narrative components of the design. For example, children's fascination with particular subjects—like trains, animals, or mythical creatures—motivates designers to integrate new content. E3 recounts a striking instance:

> "The blind students were particularly interested in the vehicles...they offered to find out what these tools actually looked like...They said, 'We know about dogs and cats, but what about a wolf? How does a wolf's body differ from a dog's?' So we ended up adding a new tactile panel with a comparison. In a way, they co-authored those expansions." (E3)

Also, children's participation is essential at the validation stage, where final prototypes must undergo real-world classroom use. Experts repeatedly emphasise how children's remarks—whether praising certain tactile details or lamenting that "*this shape is still unclear*"—become the ultimate test:

> "Instead of a small number of interviews or formal tests, we rely on actual usage in class. Children's spontaneous responses—like if they keep pausing at one corner—show us exactly which parts to fix" (E2).

In this sense, children's sustained engagement in repeated classroom trials ensures that designers and teachers adapt swiftly. The final iteration, therefore, is an authentic co-creation, validated through numerous tactile encounters in which children articulate triumphs (finding an object quickly) and frustrations (losing track of details). Their involvement, according to experts, is not a courtesy but a foundational ingredient for meaningful accessibility and consistent improvement.

7.2.2 Power Dynamics

Designers occupy a pivotal role as arbiters of accessibility, their decisions encoding ideological and practical priorities into tactile and Braille materials. E1's reflections underscore how designers' choices—font size, tactile image clarity, material sustainability—are not merely technical but deeply ethical, balancing efficiency with the imperative to "*open doors to knowledge*" for PVI. This authority, however, is neither monolithic nor unidirectional. E2 emphasises the multidisciplinary demands of TG design, where cognitive psychology and ergonomic research intersect, compelling designers to synthesise disparate fields into coherent, user-centric solutions. E3's work on standardising tactile graphics further illustrates how designers institutionalise norms through guidelines, effectively codifying what constitutes "legible" or "effective" design. At the same time, this influence is shaped by feedback. Responses from VIC and educators regularly prompt revisions, aligning expert practice with lived experience through iterative testing and co-design. The expert emphasises,

> "A solid foundation of knowledge is key. Accessible design and tactile graphics design involves knowledge from multiple disciplines, including design theory, cognitive psychology, materials science, computer science, and more. Therefore, to make progress in this field requires extensive study of the fundamentals of these fields. Understanding the workings of the human perceptual system, especially touch and vision, is fundamental to designing effective tactile graphics. It is also

> vital to familiarise yourself with standards and regulations for accessible design. These regulations not only provide guidelines for design, but also help you understand the legal framework and social responsibility of design." (E2)

> "It is also very important to keep an open mind and a continuous learning attitude. Accessible design and tactile graphics design is an ever-evolving field, and the emergence of new technologies, materials, and theories continues to push the field forward. Therefore, as a researcher, you need to keep an open mind, be open to new knowledge, and keep learning. Attending academic conferences and seminars, reading the latest research literature, and communicating with your peers are all important ways to maintain a cutting-edge perspective." (E2)

Teachers, armed with pedagogical insight and proximity to VIC, exert a subtler but no less potent influence, shaping design outcomes through their expertise. E1 acknowledges this dynamic, noting the reliance on "*collaboration with visual and tactile experts*" and the integration of "user feedback," often mediated by teachers who bridge classroom realities and design intentions. This influence manifests as a corrective force, ensuring that tactile books align with VIC's cognitive and educational needs. This expertise extends beyond mere implementation; teachers curate and adapt materials, as seen in E3's tactile textbooks, where teachers' input dictated the inclusion of interactive elements to enhance engagement.

Also, materials, far from passive substrates, assert their own agency, constraining and enabling the co-design process in profound ways. E1 highlights their recalcitrance, noting the "*high technical barriers*" of mechanically produced tactile books, which demand "*complex processes and equipment maintenance*." E3's experimentation with "*microencapsulated thermal foam paper*" and other innovative substrates underscores materials' enabling potential, yet also their capriciousness: achieving "*high-quality touch graphics production within a limited budget*" required iterative testing to balance cost and efficacy. Thus, materials function as mediating artifacts, their properties constituting a third activity system that intersects with design and pedagogy. Their agency—evident in how they resist or yield to human intention—reshapes power dynamics, compelling designers and teachers to adapt to nonhuman constraints.

Therefore, materials are not mere tools but active participants, their affordances and limitations scripting the possibilities of tactile book creation.

7.2.3 Materials Mediation

Materials are the foundation of tactile accessibility: they make abstract information graspable for VIC. E1 emphasises that tactile images need clear lines and simple shapes, often achieved with raised paperor contrasting textures to strengthen tactile feedback. These are deliberate design decisions, not incidental choices, enabling VIC to distinguish and interpret content through touch. As E1 suggests,

> "Different materials have different tactile sensations; softer materials may be more suitable for touching tools that are used for long periods of time, while harder materials are suitable for graphics that require fine tactile perception. In addition, the durability and ease of cleaning of the material is also a factor to be considered, especially in educational and public facilities where touch graphics need to be able to withstand frequent use without damage. When selecting materials, we usually test their tactile effects and durability through several experiments to ensure that the final design is both comfortable and durable." (E1)

Similarly, E3's partnership with educators led to the adoption of "*black paper of certain thickness and density*" for TG, optimising contrast for low-vision users while ensuring structural integrity. Such collaborations dismantle hierarchies between "expert" and "user," positioning material selection as a democratic process. As E3 observes, feedback from visually impaired students on colour contrasts and texture preferences informed revisions to design guidelines, transforming materials into sites of co-creation. This iterative reciprocity underscores materials as mediators of social equity, where inclusivity is negotiated through shared agency.

Material limitations—economic, technical, and sensory—curtail the idealism of accessible design. E1 critiques the "*high production costs and technical barriers*" of mechanically produced tactile books, where precision in embossing demands costly equipment and specialised labour. These economic constraints exacerbate disparities, as underfunded institutions struggle to procure durable, high-quality materials, perpetuating a "*cycle of scarcity*." E2 identifies tactile perception's "*linear and sequential*" nature as a cognitive constraint. Materials must simplify visual complexity without erasing informational nuance—a paradox evident in tactile books, where spatial depth is reduced to symbolic lines and dots. The challenge lies in avoiding "*semiotic overload*," where excessive detail overwhelms haptic processing. He highlights,

> "Haptic perception is slower and information acquisition is linear rather than holistic. This means that when designing tactile graphics, one needs to consider the decomposition and reorganisation of information to simplify complex visual information into a form that is easy to touch and understand. Through experiments and observations, I have analysed the cognitive processes of visually impaired people of different ages and backgrounds when touching graphics, and gradually developed tactile design principles suitable for visually impaired people." (E2)

Therefore, materials mediate accessibility not merely through their physical properties but through the socio-material networks that govern their selection, application, and limitation. They are both enablers and interrogators, demanding continual renegotiation of design ethics, user agency, and ecological stewardship.

7.2.4 Collaboration and Communication

The interplay between designers and educators emerges as a cornerstone of effective material development. E2 underscores that tactile graphics design is not merely a technical endeavour but a pedagogical act, necessitating "*close collaboration with special education teachers to ensure designs align with curricular objectives and cognitive frameworks*." E3 recounts a project where university design students collaborated with blind school teachers to develop tactile books, merging artistic creativity with pedagogical pragmatism. Such partnerships dismantle disciplinary silos, enabling teachers to articulate the nuanced needs of students—such as age-specific tactile sensitivity or curriculum alignment—while designers innovate within these parameters. As E1 observes, the Braille publishing industry thrives on "*like-minded colleagues*," including educators, researchers and social workers, who collectively refine materials to mirror the lived experiences of VIC. E1 emphasises,

> "Braille publishing involves a number of processes, including editing, designing, typesetting, proofreading, printing, etc., each of which requires a high degree of collaboration. It is only by working together as a team that we can ensure that the quality of the final product meets the expected standards. Therefore, as a member of the team, you need to have good communication skills and a collaborative spirit, and be able to work closely with other members of the team to solve all kinds of problems encountered in the work." (E1)

> "The interdisciplinary collaboration helped us to apply tactile graphics design to more diverse areas. By collaborating with experts in the fields of pedagogy and special education, we have integrated tactile graphics design into the development of educational resources, providing more effective learning tools for visually impaired students. This collaboration has enabled us to integrate design theory and educational practice to develop tactile graphics design products with more educational value." (E2)

Iteration emerges not as a procedural formality but as a commitment to perpetual refinement. E2 describes design as a "*cyclical mechanism*" of prototyping, testing, and recalibration, where each iteration responds to the friction points uncovered by users. Each of the TG for the tactile books went through a process of discussion and iteration by the design team—sending to experts for review—feedback from visually impaired students—and then revision. Similarly, E1 highlights the evolution of Braille textbooks, where early versions—critiqued for dense layouts—were reconfigured through dialogue with teachers to prioritise tactile legibility and cognitive pacing. This negotiation extends to material choices: E3's experiments with eco-friendly substrates and embossing techniques evolved through cycles of feedback, balancing durability with tactile nuance. The process, as E1 summarises, is "*both meticulous and mutable*."

7.2.5 Accessibility and Inclusion

Tactile recognition is the linchpin of accessible design, E2 frames this as a "*translation of sight into sensation*," where designers need to distill complex visual information into tactile symbols intelligible to fingertips. Taking the design of butterfly (Figure 7.1) as an example, the specific steps are as follows:

(1) Analysing the characteristics that people remember about butterflies, such as antennae and bow-shaped wings.
(2) Choosing a suitable angle that effectively showcases these features.
(3) Decomposing the object into its constituent parts, such as the head, body, and wings.
(4) Transforming these parts into basic geometric shapes. Biederman's recognition-by-components (RBC) theory suggests that the structure of complex objects can be broken down into simple components, called geons (Biederman, 1987).
(5) Adding simplified features of the butterfly while maintaining the geometric structure, such as long antennae, wings approximately in the shape of a bow with patterns, and a body in the shape of an elongated oval with horizontal lines.

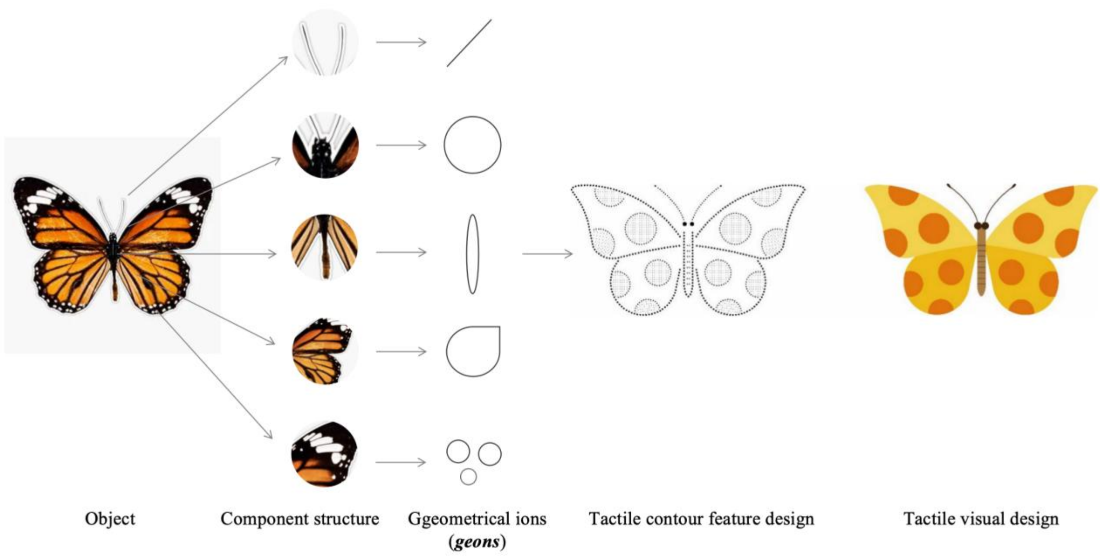

Figure 7.1. Distribution design of contact information point for butterfly.

However, the tension between pedagogical depth and tactile simplicity is a tightrope walk, requiring designers to harmonise cognitive rigour with sensory accessibility. E2 recounts the pitfalls of overambition: early prototypes of science textbooks, laden with intricate tactile diagrams, overwhelmed students, necessitating a return to "hierarchical minimalism." This philosophy, as E1 elaborates, prioritises "clarity over comprehensiveness," such as replacing dense Braille paragraphs with bulleted tactile summaries in large-print textbooks. Even the choice of binding methods, as E1 notes, reflects this equilibrium: spiral bindings allow pages to lie flat for unimpeded tactile exploration, while glue bindings prioritise durability for frequent use. The result is a design ethos that, in E2's words, "*whispers guidance rather than shouting instruction*." E1 explains,

> "Flip through a large-print book, readers will find the layout unattractive, with a large centre of the page, a large font size, and no illustrations, which is very dull. This is true, but it is set according to the visual characteristics of children with low vision. Narrowed field of vision is one of the main characteristics of children with low vision, and they are unable to capture an illustration in its entirety, even with the help of instruments such as magnifiers and dilatometers. In order to help them perceive a complete picture, it is necessary to divide the picture into if thousand parts, magnify it, present it to them one by one in order, and view it repeatedly in order to form a complete impression. Therefore, for them, there is no need for large-print books with illustrations, because 90% of the low-vision children cannot get an overall concept of the illustration, so the large-print books published by the China Braille Press are mainly textual, and they do not make much effort on illustrations. As for the cover. If it is a social reading book. The designers will try to follow the style of the books on the market, so as to make the appearance of large-print books more fashionable and elegant, so that people will have the desire to hold them in their hands and read them." (E1)

More importantly, VIC are not a monolith but a constellation of individual needs, shaped by age, residual vision, and cultural context. E1 emphasises the spectrum of visual impairment, from low-vision learners who benefit from high-contrast colours to those reliant solely on touch. For instance, tactile books for toddlers integrate olfactory cues (e.g., scented pages for fruits) and auditory elements (e.g., animal sounds), while teenagers engage with Braille-enhanced 3D models of historical landmarks. E3's collaboration with cognitive psychologists revealed another layer: children with heightened tactile sensitivity required finer embossing, whereas others thrived with bold, simplified graphics. This plurality extends to cultural nuance, as E1 notes regional adaptations in Braille materials, but this issue cannot be solved in China at the moment.

7.2.6 Contextual Influences

The creation of tactile and Braille materials unfolds within a tapestry of external forces—policy mandates, technological tides, and communal ethos—that collectively sculpt the boundaries and possibilities of design. E1 highlights how China's revised Law on the *People with disabilities act of the Peoples Republic of China* "codified the country's responsibility" to support Braille publishing, catalysing partnerships between government-funded presses and grassroots educators. Yet such frameworks can also become rigid: E3 observes that policy often lags behind practice, and older rules may constrain innovations in tactile dimensionality. By contrast, E1 highlights Finland's library led tactile book programmes state supported but community anchored, as examples where policy enables rather than prescribes co-design, keeping dialogue open between institutions and practitioners.

Technological advancements unfurl as both catalyst and canvas in the co-design of tactile books, expanding the horizons of possibility while introducing new complexities. E1 celebrates the advent of digital tools, observing that "*digital publishing and electronic Braille technology have been widely applied*," streamlining production and enhancing accessibility for VIC. This technological leap, she asserts, reduces costs and accelerates dissemination, enabling a broader reach. The expert explains,

> "The development of digital technology has made audiobooks more prevalent and easier to access. Through specialised audio players, smartphones, or computers, blind individuals can listen to books and articles of interest anytime and anywhere, significantly enhancing their reading efficiency and convenience...It can be said that digital technology has greatly alleviated the limitations inherent in traditional Braille publications in terms of production, distribution, and accessibility, providing the visually impaired with a richer and more convenient range of reading options." (E1)

E2 combines technology and experience in designing books for visually impaired students, envisioning an "*assistive AI system*" that integrates finger tracking and machine vision to enrich multisensory engagement. Yet E2 cautions against techno-utopianism, recalling early e-Braille readers that marginalised older users unfamiliar with digital interfaces—a reminder that innovation must be tempered with generational literacy. As E1 highlights,

> "This is particularly true for older visually impaired individuals, who may be more accustomed to traditional printed Braille books and may encounter difficulties when operating digital devices. Additionally, the cost and maintenance of digital devices can be a barrier for some visually impaired individuals in accessing these resources." (E1)

> "While digital technology brings new possibilities for Braille publications, it cannot completely replace traditional Braille publications, especially in the educational field. The tactile reading experience and benefits provided by traditional Braille cannot be fully replicated by audiobooks and e-books. Therefore, while promoting digitalisation, it is also necessary to continue supporting and developing traditional Braille publications to ensure that visually impaired individuals can choose the most suitable reading method according to their needs." (E1)

Social norms influence which learning materials receive attention and investment. E1 observes a cultural shift in China: where Braille books were once charity projects, rising public literacy about disability rights has recast them as "non-negotiable educational entitlements." This shift is echoed in grassroots efforts, such as volunteer networks crafting handmade tactile books for blind schools, their labour a rebuttal to market-driven apathy. Yet community norms can also enforce limitations. E1 critiques the lingering perception of tactile design as a "*niche service*" rather than a universal imperative, citing libraries that tokenistically acquire Braille books without training staff to promote them. E1 observes,

> "Since the quality and effectiveness of handcrafted tactile books depend on the skill level of the volunteers and creators, there may be some variability in their quality and outcome. There are also some volunteers who rely too much on their own ideas for production and are not willing to listen to expert advice, resulting in a lot of time spent on production but not being able to use it." (E1)

In this interplay of policy, technology, and communal will, accessibility becomes a mirror reflecting societal priorities. As E2 reflects, "*A Braille book is never just ink and paper—it is a verdict on who we deem legible*."

7.3 Cultivating a (Co-) Design Mindset and Skills

All participants appreciated design from a process perspective, showing heightened awareness of—and a critical stance toward—methods that could strengthen their existing design practice. In the prototyping session, I demonstrated how adopting a design mindset can benefit learning experiences not only at the scale of teachers' current work but also across multiple levels—from the design of individual activities or assessments to broader educational initiatives. This design mindset is characterised by a systematic, step-by-step approach that starts with broad design considerations and progressively incorporates finer details. It is centred on the needs and experiences of VIC, and it emphasises the thorough development of design outputs, such as tactile books, to ensure they meet rigorous standards of accessibility and inclusion, as highlighted during our collaborative design process.

7.3.1 Design Concepts

The model as presented in section 4.6.4 has five main key steps for cycling, and I specifically describe these processes in this section.

Idea

Initially, I convened with the teachers to decide that our prototype should take the form of a tactile book. In China, there exists no illustrated tactile book, and we envisioned this project as a means to help children grasp the inherent mirroring and symmetry of Braille characters. Chinese Braille is organised into 22 groups, each composed of symbols that are intrinsically symmetrical. As Braille is a compulsory subject for visually impaired children, the concept of mirroring can serve as a vital mnemonic and conceptual tool; however, conveying the abstract notion of "symmetry" solely through verbal explanation proves insufficient.

Following extensive preliminary research and communication, we identified our target audience as visually impaired children aged four to eight. Consequently, the design had to be tailored to meet the unique developmental and sensory needs of this age group. Before proceeding to prototype development, the teachers and I held in-depth meetings to examine existing production methods for tactile books, address current shortcomings in these techniques—including the challenges of Braille printing—and define the desired final outcomes.

Subsequently, we deliberated on the narrative to be embedded within the tactile book. The teachers proposed three distinct stories, and through careful discussion and interactive oral feedback sessions with the children, we ultimately selected a story centred on bread. This narrative was chosen for its simplicity and its natural appeal—food-related themes tend to resonate well with young children (Figure 7.2). To support the story, we procured tactile models of bread. These models were engineered to withstand repeated pressing without damage and even carried a subtle bread aroma. Their realism was so compelling that when I removed a bread model from a child’s hand, the child cried and insisted on its return, even attempting to taste it.

《凹凸面包镇》
The Concave-convex Bread Town

在遥远的哇哇国，有一个名为凹凸面包镇的奇妙地方。
In the distant land of Wawa, there lies a magical place named the Concave-convex Bread Town.
木匠哇呜呜是镇上唯一会制作面包模具的工匠。哇呜呜的手艺非常好，以至于面包大婶哇吁吁每次都会选择使用他的模具来制作面包。哇吁吁的面包款式非常多：
The carpenter, Wawuwu, is the only artisan in the town skilled in crafting bread molds. His craftsmanship is so exquisite that the baker, Aunt Wayuyu, always chooses to use his molds for her baking. Wayuyu's bread comes in many styles:
三角形的糖面包，圆形的豆沙面包，长方形的巧克力面包，还有像扇贝一样的果酱夹心面包
Triangular sugar bread，Round bean bread，Rectangular chocolate bread
And a jam-filled bread resembling a scallop
（增效不同面包的形状） (Make enhanced tactile impressions of different shapes of bread)
一天，镇长哇窝窝和未婚妻哇唉唉要举办婚礼。
面包大婶哇吁吁决定送印着他们名字“窝窝唉唉”的面包表示庆祝。
One day, the town's mayor, Wawowo, and his fiancée, Waaiai, were set to have their wedding. Aunt Wayuyu decided to present them with a bread stamped with their names "Wowo Aiai" as a celebratory gift.
木匠哇呜呜将模具做好了，面包大婶哇吁吁看了看说：“哇呜呜，模具上写的是‘唉唉窝窝’，你是不是刻反了？”
Once Wawuwu finished the mold, Aunt Wayuyu took a look and exclaimed, “Wawuwu, the mold says 'Aiai Wowo'. Did you engrave it backward?”
（增效面包模具‘唉唉窝窝’） (Make enhanced tactile impressions of the mold 'Aiai Wowo')
哇呜呜说：“没错！没错！你烤好面包就知道了！”
Wawuwu replied, “It's correct! Just bake the bread, and you'll see!”
果然，当面包烤好后，名字的顺序正好是“窝窝唉唉”。
Sure enough, once the bread was baked, the names appeared in the right order: "Wowo Aiai."
（增效面包‘窝窝唉唉’） (Make enhanced tactile impressions of the bread 'Wowo Aiai')
原来，面包模具要左右反着雕刻才可以！
It turned out that for the bread mold, the engravings needed to be reversed!
婚礼当天，定制的面包引起了轰动，宾客们纷纷表示，要定制同样的面包来为自己的特殊日子添彩。
On the wedding day, the customised bread became the talk of the town. The guests were so impressed that many expressed their desire to order similar bread for their special occasions.
从此，哇呜呜每天都忙于制作各种模具，而哇吁吁则每天都忙碌于烘焙面包。
From then on, Wawuwu busied himself crafting various molds daily, while Wayuyu was always bustling with her baking tasks...

Figure 7.2. The content of the story that was eventually negotiated with the teacher.

The story itself, composed of ten succinct sentences, unfolds in a small town where a mould-making carpenter and a bread-making lady play central roles. For the mayor's wedding, a special bread was crafted, bearing the names of the mayor and his wife. Notably, the inscriptions on both the mould and the finished bread were rendered symmetrically—a detail that encapsulated the book's thematic focus on mirror imaging.

Early design

After reaching a consensus with the teachers on the form and content of the learning materials, we embarked on the creation of the initial design draft (Figure 7.3). In this early stage, I, as the designer, took the lead. Our discussions centred particularly on the style and chromatic composition of the illustrations. Among various aesthetic approaches, we embraced a flat design style—a choice that emphasised clarity and simplicity.

Despite the visual impairments of the target audience, previous research confirmed that both low-vision and fully blind children possess an intrinsic understanding of colour. Through verbal descriptions—explaining, for instance, that the grass is green and the sky is blue—children develop a perception of colours. Consequently, the teachers were unanimous in their insistence that the visual illustrations should not be omitted; rather, they should complement the tactile elements. The adopted style was thus defined by its high contrast and ease of recognition, employing expansive, bold areas of primary colours such as red, yellow, blue, and green.

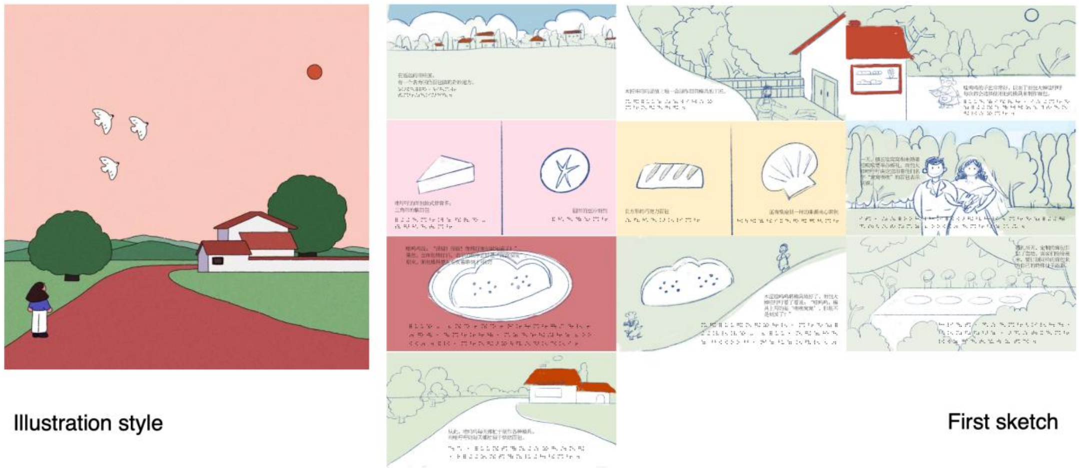

Figure 7.3. Sketch of the design for the first edition of the Concave-convex Bread Town.

Based on the teachers' detailed feedback on the initial draft, I proceeded to make the corresponding refinements, ensuring that the design met both inclusive and pedagogical standards.

Redesign

In the second design iteration, we delineated the precise content for each page and identified the sections requiring "augmentation" (Figure 7.4). Here, augmentation refers to the strategic incorporation of materials aimed at deepening the understanding of VIC. Once we confirmed the revised aesthetic and functional approach, the teachers and I proceeded to engage the children in testing various materials, examining not only the choice of materials but also their placement and adhesion methods on the pages.

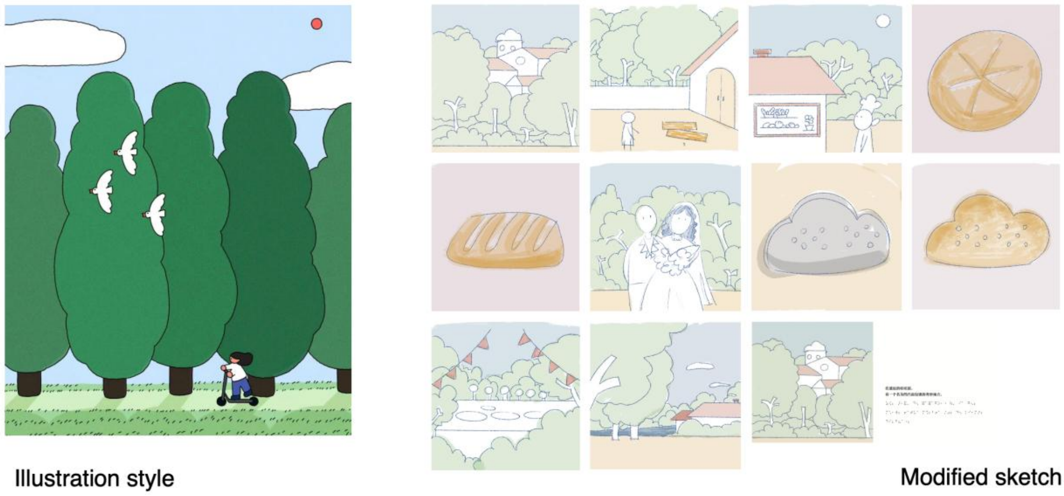

Figure 7.4. Sketch of the design for the secondary edition of the Concave-convex Bread Town.

Concurrently, I arranged the preliminary drafts of the illustrations alongside the corresponding text. However, upon printing, it became apparent that if the Braille text were dispersed haphazardly—mimicking the layout of a conventional illustrated book—it would cause considerable confusion. The children, when transitioning to a new page, found themselves compelled to search for the beginning of the text anew. To address this issue, I redrew the layout, refining the design to ensure a more logical and consistent placement of the Braille, thereby enhancing the overall reading experience.

Test

The careful selection of materials was of utmost importance—this encompassed not only the dimensions and thickness of the paper but also the tactile qualities of every component. For the "augmentation" segments on each page, we assembled a range of tangible objects to help the children concretely discern abstract terms such as "bread," "carpenter," and "wedding" (Figure 7.5). I printed out the preliminary drafts and affixed them onto sturdy cardstock, inviting both children and teachers to explore and experience the textures firsthand (Figure 7.6).

Figure 7.5. The teacher allows VIC to make choices about different materials.

Figure 7.6. The teacher allows VIC to make choices about different materials.

A critical issue that emerged was the optimal placement of the Braille text—whether on the right or left side of the page. Our tests revealed that the children naturally gravitated toward engaging with Braille on the right-hand side (Figure 7.7). In response, I implemented this configuration on two prototype pages featuring the augmented elements, thereby enabling each child to assess the size, positioning, and tactile quality of these materials. Although the children were able to clearly identify objects such as bread and wood, I observed that they tended to pull on these elements with excessive force. The temporary use of double-sided adhesive to affix the components nearly resulted in the models coming apart under such vigorous handling.

Although the design, content, and layout have been established, it is crucial to integrate the printed and augmented components in a way that prevents them from being easily damaged—especially given that some children may handle the book roughly.

Figure 7.7. Designers and teachers discuss the left and right orientation of illustrations for final printing.

Implement

The production phase revealed that printing costs were exceptionally high. With the invaluable assistance of the teachers, I identified two manufacturers capable of printing Braille books. However, due to the limited print run required, both the setup fees and per-unit printing costs proved to be disproportionately steep. Despite these financial challenges, the final printed edition (Figure 7.8) garnered unanimous acclaim from both visually impaired children and their teachers.

Although certain finer details remain in need of refinement, the process itself proved profoundly educational: the children were introduced to a range of materials, actively engaged in the design process, and developed an initial familiarity with Braille. This edition, while representing the culmination of our current prototyping efforts, simultaneously serves as the inaugural version for use in the upcoming academic year. Moreover, the teachers have committed to a continual cycle of feedback with successive cohorts, ensuring that future iterations will be rigorously improved in both durability and pedagogical effectiveness.

Figure 7.8. The final printed version of the tactile books.

7.3.2 Designing as a Way of Being

During prototyping, the designer transforms from a conventional problem solver into a weaver of tactile tapestries, each thread embodying the conviction that inclusion is co-created with people rather than designed solely for them. A range of design focused aspects developed through the interdisciplinary collaboration were shared by prototyping. These are presented schematically in Figure 7.9 and reported in more detail in this section.

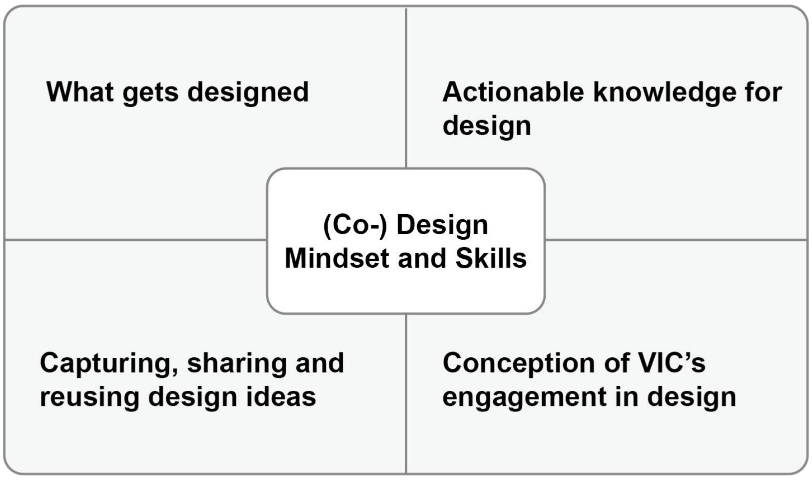

Figure 7.9. Key design mindset and skills aspects based on prototyping process.

What gets designed

To begin with, learning cannot be designed. Neither can activity or experience be designed. They can be designed for (Wenger, 1999). In the context of VIC education, I contend that the essence of design lies not in the fabrication of learning itself, but in the creation of conditions and materials that enable learning to flourish; the products of design are best understood as dynamic supports for learning, rather than static outcomes. In this context, the designer's role transcends the mere fabrication of tactile books—it encompasses the orchestration of materials, experiences, and social practices that collectively scaffold the learning process.

The tactile books that emerge from co-design processes are, at their core, mediating artifacts—objects that bridge the gap between abstract knowledge and sensory experience. These materials are designed to be multisensory interfaces, integrating visual, tactile, and even olfactory elements to create a rich, immersive learning environment. However, what gets designed is not limited to the materials themselves. It also includes the processes and practices that facilitate their use. The iterative design process—characterised by prototyping, testing, and refinement—is itself a designed intervention. Each iteration responds to the friction points uncovered by users, ensuring that the final product is not just functional but also pedagogically effective.

The co-design process itself becomes a site of learning for all participants. Teachers, designer, and children engage in a negotiated practice, where expertise is shared and hierarchies are destabilised. Teachers contribute pedagogical insights, designers bring technical knowledge, and children offer experiential feedback that shapes the design in profound ways. As E3 recounts, children's fascination with vehicles led to the expansion of tactile book content, effectively co-authoring new segments. This collaborative engagement transforms the design process into a learning community, where the boundaries between "designer" and "user" blur, and the focus shifts to collective problem-solving.

Finally, the design of social interactions is another critical dimension of what gets designed. The tactile books are not merely static objects but social artifacts that mediate relationships between VIC, teachers, and peers. For instance, the inclusion of interactive elements in tactile books—such as removable models or audio cues—fosters collaborative learning, where children and teachers explore the materials together. These interactions are designed to be participatory, encouraging children to take an active role in their learning and fostering a sense of ownership and agency.

Actionable knowledge for design

In the domain of educational practice for VIC, knowledge for design transcends mere theoretical sophistication; it must be able to inform timely and ethically responsible action. In other words, teachers and designers cannot stay in prolonged uncertainty; they must make decisions with incomplete or contested information. In daily work, teachers choose tasks, tools, spaces, and social arrangements under tight schedules. The unyielding deadlines imposed by institutional timetables, sharpen the requirement for actionable knowledge.

Crucially, teachers and designers need to understand where, and how far, their agency may extend. Sometimes, small modifications in a curriculum or the reordering of an activity sequence offer the best that can be done; at other times, a more radical reframing of teaching problems may prove essential. In certain contexts, existing norms and resources heavily constrain the scope of possible design solutions; in others—especially in more experimental or pilot settings—teachers and designers may enjoy an uncommon liberty to innovate (Chapter 5). However, such freedom to act is neither trivial nor guaranteed. It reflects the moral imperative placed upon educators to do the best they can for their students within bounded circumstances

Design knowledge in educational settings, therefore, entails more than the refinement of propositions or the quest for universal truths. It must support the work of invitations—the ways designers encourage others to behave, respond, or experiment (Goodyear, 2015). These invitations can be crystal clear in a worksheet prompt, or tacitly encoded into the affordances of a material artefact. In either scenario, the "designerly" challenge is to anticipate how learners or fellow practitioners will respond. A substantial corpus of the human sciences—drawing on disciplines such as psychology, anthropology, ergonomics, and economics—nourishes exactly this type of second-order knowledge. When a teacher-designer wonders, "How might children engage, in practice, with this tactile representation of a geometrical concept?" she is relying upon precisely such knowledge to hypothesise and adjust her design.

Design knowledge in VIC education, then, bridges knowledge structures traditionally labeled 'positivist'—for instance, in anticipating how physical materials operate within defined constraints—and 'interpretivist,' attuned to the capricious reality of human interaction and response. To prototype a tactile book that uses complex layouts, the teacher-designer must integrate both scientific understanding (e.g., how to ensure durability and clarity in the materials produced) and interpretive awareness (e.g., how VIC might react affectively or cognitively to those newly introduced materials). The resulting "epistemic fluency" (Goodyear, 2015) joins two heterogeneous forms of knowing, enabling teachers and designer to map technology, content, and participant needs into workable solutions within pressing temporal, institutional, and ethical boundaries.

Finally, it is not merely knowledge of design but knowledge about design processes themselves that empowers teachers to adapt to shifting needs. The dialectic between “organic” design—where local teachers contribute piecemeal improvements within existing systems—and “strategic” design—where a broader intervention aims to redirect a system under external pressures—illustrates how different conceptions of design knowledge can be activated. Co-design exemplifies a hybrid approach, whereby designer import novel concepts into a particular educational environment and collaborate with local inhabitants (i.e., teachers and VIC) to iterate and refine interventions. To be truly actionable, design knowledge in education requires a confluence of theoretical acuity, principled improvisation, and the willingness to reframe persistent problems from fresh angles.

Capturing, sharing and reusing design ideas

The question of how teachers and designer might capture, share, and reuse their pedagogical designs—rather than simply finished resources—has been a persistent challenge in inclusive education. Indeed, teachers have long been reluctant to adopt instructional products designed by others, citing context-specific concerns or the sheer time-cost of discerning whether another’s materials align with local needs. Not until the recent explosion of readily searchable online networks have we begun to see incremental shifts in this cautious disposition. Children’s rapidly evolving practices and expectations, along with growing institutional pressures to modernise teaching, have further eroded older habits of pedagogical isolation, obliging educators to look outward for potential design solutions.

In prototyping practice, however, two key obstacles have stymied these ambitions. First is the perennial challenge of making tacit design knowledge visible. Much of the skill that underpins an effective learning design remains intimately bound to the teacher's firsthand experiences, nuanced judgements, and on-the-fly improvisations. Even the prototype designed with designer struggles to capture that fluid interplay of beliefs, contextual constraints, and children feedback that shapes a real classroom. Second, there is an infrastructural gap: while repositories of static content (e.g., worksheets) have proliferated, comparably robust channels for sharing dynamic designs (e.g., the richness of materials, the collection of tactile books stories, printing methods) are still embryonic.

Nevertheless, this prototyping developments show promise. The more teachers perceive design not simply as an output, but as a valuable knowledge asset, the likelier they are to document and share their underlying intentions for a lesson. Growing awareness of learning design methodologies, pattern languages, and iterative co-design practices has emboldened some teachers to create repositories of design ideas that can be inspected, adapted, and tested in new contexts. The emergent result, over time, may be a culture in which reusability does not merely entail uploading discrete teaching objects, but opening up the creative process so that design knowledge—especially for complex areas like inclusive or disability-focused education—can be reinterpreted and repurposed across institutional and cultural boundaries.

Conception of VIC's engagement in design

VIC bring to the (co-) design table more than simply a set of learning objectives; they also bring their own interpretive frameworks, experiential knowledge, and creative impulses. Hence, how we conceive of their engagement in design can profoundly shape both the learning experience and the ultimate design outcomes. In many conventional educational contexts in China, there is a tendency—often tacit—to understand learning through what Sfard (1998) describes as an "acquisition" metaphor:

in other words, learning is framed as the personal accumulation of certain skills or know-how. While such an orientation certainly has its merits, especially when educators are trying to systematically equip VIC with specific tactile reading techniques or orientation-and-mobility competencies, it overlooks the broader possibilities of "learning as participation" and "learning as knowledge creation".

In the realm of learning as participation, children are not mere recipients but active members of a practice—be it braille literacy, collaborative storytelling, or co-create tactile materials. They assimilate the tools and conventions of that practice, not solely to improve their own mastery but to contribute to and transform the design practice itself. In the interviews, teachers and experts also revealed that they had adopted this participatory approach to learning without being aware of it. For instance, rather than passively "learning about" how a tactile diagram is made, students took charge of small but pivotal decisions, such as adjusting raised-line thicknesses or selecting a more intuitive shape for a braille label.

By contrast, when we embrace learning as knowledge creation, we acknowledge that students do not merely adapt existing resources; they co-invent and shape entirely new artifacts or systems. In this sense, the co-design process itself becomes both the site and the product of learning. In the prototyping observed, some VIC expressed imaginative proposals for novel multi-sensory materials—sometimes weaving in tactile prompts, audio cues, or experiential components unanticipated by designer. For example, the children showed a strong love for bread when we started to choose the story topics for the tactile books, or the children's strong desire to add cars to the books, as stated in the E3 interview.Therefore, the outcome was not just a "better" or more accessible resource; it was the direct evidence that children were creating knowledge about how to design for visual impairment-friendly experiences, effectively forging new tools that can enrich the entire community of practitioners.

7.3.3 Shifting Pedagogic Mindset

Several teachers reported a profound shift in their understanding of teaching and learning during the prototyping process. This transformation was grounded in their recognition of the intrinsic value of their own learning designs and, in some instances, reinforced by the positive responses these designs elicited from their students. They felt both motivated and empowered to explore future pedagogical approaches that would further enhance their practice. Thus, the true impetus for change often emerges not from broad institutional mandates, but from teachers' evolving perceptions of what is required to foster genuine children engagement—particularly in contexts marked by diverse learner profiles.

This movement towards a design-centric ethos represents a pivotal turning point in VIC education pedagogy. When teachers see themselves as creative problem-solvers rather than mere conveyors of established knowledge, they develop a heightened awareness of learners' varied needs and an openness to iterative experimentation. Such an orientation demands both reflective practice and receptiveness to novel tools or collaborative methods, though it also raises concerns about time, workload, and the risk of prematurely formalising half-formed ideas. Yet the benefits are clear: a design mindset enlarges the scope of what teaching can accomplish, allowing teachers to integrate deeper empathy for students, cultivate shared epistemic agency in teaching teams, and more willingly adapt or refine their materials. It is thus in this expanding conception of teaching as design (Chapter 5)—where everyday pedagogy is reconceived as iterative, evidence-based, and collaborative—that a genuine, sustainable shift in mindset can take hold.

7.3.4 Co-design as a Negotiated Practice

In the context of designing for VIC, co-design, is never merely a matter of technical problem-solving or unidirectional consultation; it is ongoing negotiation among participants with different expertise, goals, and identities. Teachers, designers, experts, and the children themselves bring overlapping but not identical priorities to the table, and what emerges as the “final product” is less a static resolution than a continuously evolving compromise. As highlighted in expert interviews and reflected in the iterative prototyping processes, the recalibration of traditional hierarchies forms a central theme in these negotiated interactions. Contrary to conventional top-down approaches, co-design for VIC relies upon a fluid redistribution of power and expertise, dynamically accommodating teachers’ pedagogical intentions, designers’ technical and aesthetic proficiencies, and—crucially—the children’s experiential insights. Materials, likewise, assert their agency within these negotiated interactions, influencing outcomes through their inherent affordances and constraints. In this sense, co-design transcends a neat division of labor—where each actor “adds a piece” of the puzzle—and instead materialises as an active interplay of decision-making, iterative prototyping, and mutual adjustment. The negotiation extends beyond pure content or functionality, encompassing tacit judgments about what is culturally or pedagogically desirable, how materials should be shaped, and who exercises authority over which elements of the design. As such, negotiation emerges not as an obstacle to be overcome but as the generative core of creative co-design—a productive tension that actively shapes materials, deepens understanding, and dynamically redefines what it means to design inclusively.

7.4 Chapter Summary

In positioning the designer as a negotiator, this chapter elucidates the intricate mediation required to harmonise intersecting activity systems: pedagogical frameworks, material affordances, and the experiential realities of VIC. Through a synthesis of expert interviews and iterative prototyping, the chapter reveals that co-design is not a linear process but a negotiated practice, where authority is recalibrated, ambiguity embraced, and materials elevated from passive substrates to dynamic collaborator.

8. Children as Co-Designers

This chapter demonstrates how co-design with VIC not only advances the material outcomes but significantly enriches pedagogical approaches, thereby expanding the conceptual and practical scope of inclusive pedagogy.

This chapter is from one published article and two articles under review:
Rong, A. & Hansopaheluwakan-Edward, N.. (2025). Uncovering facilitators and constraints in co-design with visually impaired children: A sociomateriality perspective. *The Design Journal*. DOI: https://doi.org/10.1080/14606925.2025.2477929
Rong, A. & Hansopaheluwakan-Edward, N. (2025). Invisible Visual Arts Education. *Exceptional Children*.
Rong, A. & Hansopaheluwakan-Edward, N. (2025). Co-design as Pedagogy: Understanding Materiality, Designed Form and Learning Activity with/for Visually Impaired Children. *Co-design*.

8.1 Introduction

In the preceding chapter, I explored the promising creative capacities of VIC acting in the role of designers—an endeavour that shed light on the fluid boundaries between designing for and designing with. This chapter shifts the analytical lens explicitly toward the possibilities inherent in amplifying children's agency, positioning them as active participants and co-designers in the design of educational experiences and materials by combining the roles of material-people-practice-process participants. The workshops demonstrate the possibilities inherent in shifting traditional power structures by placing VIC in the co-designer's seat. As such, this chapter specifically responds to **RQ4**: "*What are the key features of the co-design process involving visually impaired children*?" In addressing this query, the argument pivots on the notion that co-design—far from being a straightforward tool—is a deeply relational and context-sensitive practice. Co-design does not merely enfold VIC into a predetermined creative schema; it reconceptualises creative labour itself by weaving together each child's sensorially attuned perspective, experiential knowledge, and desire for meaningful interaction.

In both workshops, prompts were designed with three purposes: (1) to warm up and elicit children's existing repertoires and interests (ice-breakers and low-stakes ideation cues); (2) to scaffold concept formation and collaborative making (sequence cues that staged brainstorming, hands-on composition, and peer feedback); and (3) to surface reflection and next-step decisions (closing questions about what to keep, change, and try next). Typical examples included warm-up cues (e.g., "Tell us one thing you explored with your hands today"), process cues during co-designing (e.g., "What does this texture stand for in your scene?"), and reflection cues (e.g., "Which part was hardest/easiest?"). For the full scripts, materials lists, and minute-by-minute activity flow used by teachers and designer, see Appendix F (full workshop process), and the workshop overviews in Tables 4.8 – 4.9. For the children background forms used to tailor prompts to each child, see Appendix G.

By the close of this chapter, I will have mapped out the defining features that render co-design both a participatory ethos and a pedagogical practice. This has enabled me to explore the co-design process involving. VIC intended as an activity system, and to identify the following features of the learning activity: it was (1) role shifts, (2) generative, (3) self-reliant, and (4) divergent, and it had (5) a fluid hierarchies. Such an environment, we shall discover, catalyses a deeper transformation in attitudes, expectations, and relationships among everyone involved—VIC, teachers, designers, and guardians alike. It is within this transformation that co-design's most significant promise lies: inviting all participants to become co-authors of both knowledge and change.

8.2 Workshop 1, Dragon

The overview for workshop 1 was in Tables 4.8 and reproduced the full process in Appendix F. Figure 8.1 illustrates the workshop process by outlining the sequence of activities and spatial arrangements.The workshop followed a consistent arc: (1) orientation (audio introduction, space/materials familiarisation); (2) constrained exploration (handling candidate materials/tools); (3) focused making (individual segment work with periodic teacher prompts to link parts to the whole); (4) collective assembly (bringing segments together and negotiating final adjustments); and (5) guided reflection (children describe their contribution and how it connects to classmates' work; teachers note learning highlights).

Specifically, at the outset of workshop, teachers introduced the theme and procedures using audio-supported explanations, followed by a guided familiarisation of the room and materials. Children were invited to touch and explore all prepared materials before any making began. In the Dragon calendar workshop, the shared task was to co-create a single collective artefact (see Figure 8.3): each child contributed one segment of the dragon's body, which was later assembled into a whole. The immediate pedagogical aims were to support understanding of the dragon's imagery and its cultural significance within Chinese tradition and to practise collaborative making; the practical outcome fed into the production of a charity calendar whose sales supported further activities for VIC. Interaction was scaffolded through turn-taking, tactile hand-over of parts, and teacher-led checkpoints that made visible how individual contributions fitted into the whole.

Designer co-planned the workshops with teachers in advance (theme selection, material lists, and an initial mock-up of the target artefact), and agreed the prompts and brief, open questions for post-activity feedback interviews. During sessions, designers supported idea development, material adaptation, and assembly logistics while deferring to teachers on classroom management and pacing. Teachers moderated pacing and transitions between phases (exploration, making, assembly, and reflection) to align with classroom rhythms and children's energy. Informal peer support was encouraged (e.g., children describing their part to peers during assembly) to strengthen joint ownership of the final co-designed artefact. Guardians were present to provide practical assistance when needed (e.g., bathroom breaks, managing personal items) and to help maintain children's comfort and focus. As is common in family-inclusive settings, a small number of guardians occasionally attempted to intervene in the making out of concern for completion; teachers and designer responded by gently re-orienting support toward encouragement rather than doing the task for the child.

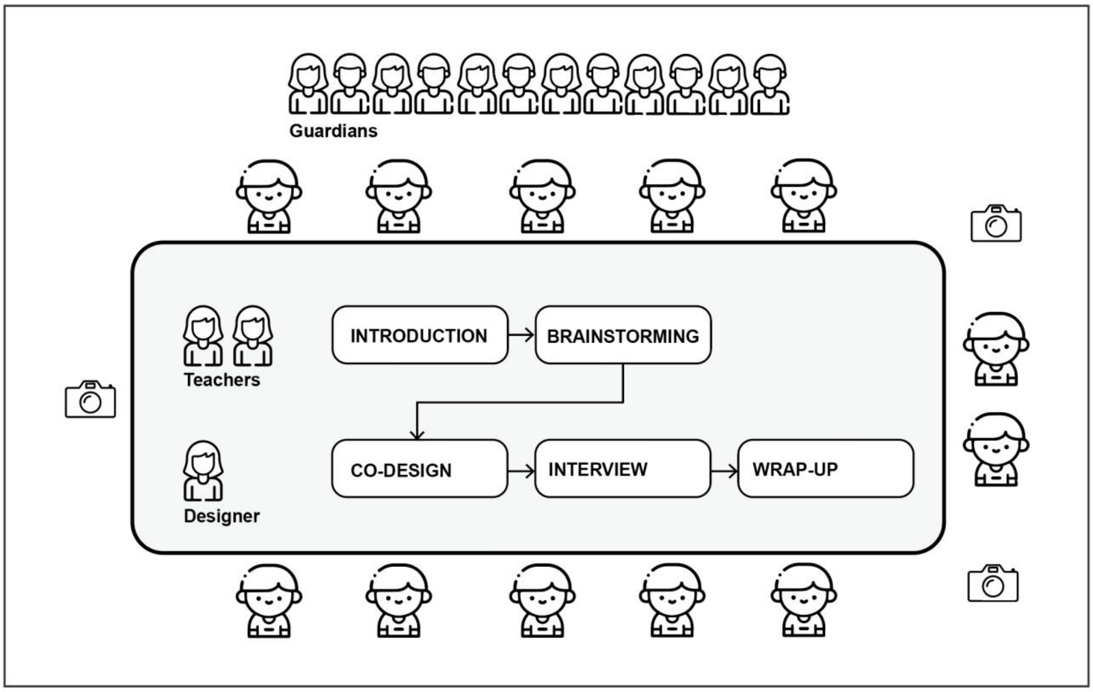

Figure 8.1. Depiction of co-design workshop process (Rong & Hansopaheluwakan-Edward, 2025).

8.2.1 Materials: Clay, Ears and Silence

The materials effectively extend the children's tactile senses, enabling them to perceive and interact with their surroundings in meaningful ways. It provides a tangible medium through which the children can express their ideas, comprehend the concepts being designed, and gather information from their environment. For example, a child might remark, "*This one feels like sequins, and it will be nice for decoration*," or enquire, "*Is this a feather? I think it is very light*." The concept of auditory enhancement in this study is defined by the use of various sound-emitting devices, audio recordings, smartphones, and even materials typically not associated with sound, such as clay and plastic, which can transform visual information into auditory formats (Figure 8.2). Clay, for example, an inherently quiet medium that yields almost no audible clues—they would lift a small piece to their ear, hoping for the faintest sound to guide their impressions. Within this dynamic, clay took on a dual role as both the subject of inquiry and the means by which children constructed and communicated their ideas. Handling clay became a tactile expedition into form, weight, and texture, and a constant invitation to wonder: children would pass small lumps from hand to hand, patting or prodding them into shapes that satisfied their vivid, if invisible, mental pictures.

Figure 8.2. The way VIC interact with materials.

Yet, the sensory possibilities that materials unlock are never unconditional. A significant obstacle arose from what can be called "tactile misunderstanding." If the textures children handled were too indistinct, or otherwise confusing, they conveyed no clear meaning—thwarting the material's intended educational purpose. For example, if materials are designed with textural differences to convey distinct information, they may be imperceptible to the children, thereby failing to communicate the intended message. This issue is illustrated in the video, where a child is seen sticking a feather in the clay and muttering to himself, "*Are dragons like birds*?" Originally, our (teachers and designer) aim was to offer a diverse range of materials to enhance the children's choices prior to starting the workshop. However, this approach inadvertently led to potential misalignments between the designer' intentions and the children's interpretations. Availability of carefully chosen tactile items also proved limiting. Tools like paints, scissors, or pencils—indispensable in many co-design sessions—often rely heavily on sight and introduce safety concerns, hence requiring continuous vigilance from teachers.

8.2.2 Subject: Anxiety

Although the designer and teachers had previously collaborated in prototyping—one that proceeded gradually and without strict time constraints—this was the first instance of bringing VIC, guardians, and even two additional volunteers together under one workshop. The collective inexperience in orchestrating so many moving parts generated a pronounced sense of anxiety. Long before the session began, all involved meticulously discussed timetables, roles, and fallback plans; yet no one could predict which unforeseen complications might surface or whether the children would fully grasp the design process and theme. The sheer unpredictability of the event—new participants, novel tasks, unfamiliar social dynamics—fueled a pervasive undercurrent of tension.

My own preparations betrayed a similar apprehension: I drafted numerous interview questions in advance, despite having interviewed VIC on prior study, and despite already knowing some of the participants personally. At the teachers' suggesting, I assembled an even larger set of prompts, anticipating moments when a child might fall silent or struggle to find a suitable response. And it did happen, during the interviews, some children repeatedly expressed uncertainty, saying "*I don't know*," and 4 out of the 12 children only had a clear recollection of the activity involving kneading clay. I noted that the children often appeared visibly confused or overwhelmed when they were unable to answer or remember in response to successive questions. The teachers themselves, too, shared in the feeling that "*we cannot be too ready*." This collective nervousness was not merely about whether the workshop would "run smoothly," but about preserving the children's sense of ownership and ensuring that each voice—from child to teacher to volunteer—found space in a newly formed creative ecosystem.

Further compounding this ambient anxiety was fatigue among the VIC. Compared to their sighted peers, VIC often expend greater effort to stay focused over an extended period, and consequently tire more easily. The phenomenon appeared starkly in video footage: some children repeated the same hand motions over and over, stared off into space, or expressed the desire to take a break. The social dimension of co-design—its pace, duration, and requirement to keep up with peers—could also heighten this exhaustion. Children might feel an unspoken pressure to perform or collaborate at a certain rhythm.

8.2.3 Object: My Imaginary Dragon

The co-design process culminated in creations and reflections that outstripped every preconceived notion of what the children would produce. When asked to articulate their conceptions of a dragon, the children proffered an array of remarkably imaginative ideas: some envisioned a beast that existed within a "dinosaur kingdom," roaring with a monstrous ferocity; others suggested the dragon could be rectangular in shape, possessing an otherworldly geometry wholly removed from the serpentine forms of popular lore (Figure 8.3). These visions, seemingly eccentric at first glance, originated from the children's layered encounters—tactile and auditory exploration, group storytelling, and their own blossoming sense of possibility. Far from adopting a uniform template, each child's dragon took on a unique architecture that spoke to the confluence of personal intuition, material cues, and the peer-driven discussions that flourished during the workshop.

Figure 8.3. VIC, teachers and designer co-designed the dragon.

Moreover, as children felt safe to create—surrounded by peers, guardians, designer, and teachers who listened without judgment—they discovered the latitude to express unprecedented ideas about what a dragon could be. I observed numerous instances of this transformative synergy. A single remark from one child—"*My dragon's wings make a whistling sound*"—inspired another child to attach feathers and plastic strips to a clay model, driven by the notion that the mystical creature might sound more like wind rushing through treetops than the conventional roar.

Perhaps the most powerful affirmation of this co-created imaginary world came in the children's expressed eagerness to continue. Many of them, interviewed at the end of the workshop, spoke with excitement about participating in future workshops, remarking on the fun they had, the sense of community, and the pleasure of working in an environment where their ideas met genuine validation. "*I really like this kind of learning activity! It's so interesting*!" one child exclaimed, underscoring how the workshop's blend of creativity and social support instilled a sense of empowerment. When children articulate a desire to rejoin the co-design process, they effectively signal that they feel valued, heard, and fully engaged—as creators of meaning rather than mere recipients of instruction.

8.2.4 Rules: Invisible Principles

The workshop was also quietly governed by invisible principles: unspoken norms and tacit frames that shaped how the co-design process unfolded. While participants seldom articulated these "rules" outright, they persisted in subtle forms—manifesting as beliefs, habits, and social cues that constrained or channeled creative expression.

Children instinctively assumed roles of mutual aid, guiding one another through physical spaces and collaborative tasks. For instance, prior to the workshop, children assisted peers in navigating stairs and corridors, verbalising spatial observations like, "*There is a big door here that can be moved*," or "*Careful here! The stairs here need two more steps.*" This instinctive generosity underscored the collective ethos that would follow: as children collaborated on their dragon designs, they often shared methods for working with materials or explained new tactile details they had discovered.

A second invisible principle emerged from familial insights. Many guardians arrived with knowledge gleaned from domestic routines—favourite tactile materials, preferred ways of handling unfamiliar textures, or gentle cues to help stave off fatigue. This practical wisdom effectively "localized" the workshop, prompting the teachers and the designer to adapt activities to the child's comfort zone. Although rarely put in writing, these parental inputs wielded persuasive power, guiding decisions during workshop on how materials were distributed, how long each phase lasted, and when breaks were offered.

A subtler—but equally impactful—principle arose from designer's own inertial thinking, the residual effects of longstanding aesthetic and procedural norms. As a designer, one might reflexively judge an output on the basis of "visual appeal"—an irrelevant criterion for VIC. Such inertial mindsets risk stifling innovation, relegating the children's needs to the background. When a "good-looking" standard is unconsciously enforced, the design process inadvertently privileges conventional aesthetics over lived experience.

8.2.5 Community: The Stranger Embodied in the Voice

When we first gathered in the workshop space, it was not the designer or the teachers who bridged the social distance among newcomers, but rather the children themselves. Those who already knew me would take a friend's hand, gently guide them close, and say, "*Listen to this voice—that's Ms. Anqi. You can even hold her hand*!" A mere vocal introduction, delivered with warmth and excitement, often sufficed to transform a stranger into a friendly presence. Yet the VIC were not merely forging these bonds with me: many had come to an unfamiliar environment altogether—new people, new materials, and at times even unfamiliar scents. In each case, the "voice," whether literally someone's tone or figuratively an inviting remark, catalysed a sense of community.

Still, the flip side of this communal welcome was the ever-present risk of inadvertent exclusion. One child remained conspicuously distant from interactions, appearing in the workshop video to linger at the edge of the space, seldom joining in conversation or collaborative tasks. On inquiry, I discovered a confluence of factors. The child had a penchant for windows and found reassurance in the natural light and air, yet the space offered only a glass sunroof, no traditional windows. In addition, the child was reticent, declining peers' invitations to engage. Without a clear means of bridging the gap, neither teachers nor fellow participants pushed harder to include him. The result was a subdued, often silent presence in an otherwise bustling design environment.

Underlying such moments is a web of intersecting social resources—institution, local charity, parent support groups—that shape the experiences of VIC well before they arrive at any single workshop. Crucially, in this workshop, a charity provided the venue free of charge, ensuring a warm, bright, and carefully maintained setting. This generosity in turn lowered the children's sense of strangeness, allowing them to immerse themselves more comfortably in co-design. While physical space alone could not guarantee seamless inclusion, its quality helped cultivate a climate in which children's curiosity might eclipse their trepidation.

Figure 8.4. Participants enjoyed taking a group photo together at the end of the workshop.

In this sense, community—like a stranger's voice—unfurls in small, often unseen gestures of hospitality. The intangible leaps from acquaintance to friend, from wary silence to joint laughter, hinge on the interplay of audible cues, emotional resonance, and spatial comfort. Through repeated acts of vocal identification—children introducing their peers by voice, guardians quietly naming teachers—newcomers came to feel less like outsiders, gradually weaving themselves into the communal fabric (Figure 8.4). Such processes reveal that co-design transcends the physical artifact; it is an invitation to forge relationships, to listen differently, and to let a voice once unfamiliar become part of a collective conversation.

8.2.6 Division of Labour: Fluidity

As the workshop reached its midpoint, what initially appeared as a conventional division of roles—teachers instructing, designer supervising, children following—began to melt away. In the early stages, the children tentatively looked to adults for guidance, unsure of which materials to choose or how to assemble their pieces. However, once they grew comfortable with tactile exploration and recognised the extent of their own creative agency, the dynamic shifted noticeably. Some children began to issue directions with quiet authority: "*Put the button over here*!" or "*We should decorate the dragon's belly this way*. *Put more of this squishy stuff on it and the feathers won't be needed*." Their voices brimmed with the confidence of newly anointed designers eager to shape the outcome.

This was not a simple reversal of hierarchy; rather, it signaled the emergence of a genuinely fluid division of labour. The children's growing sense of ownership compelled teachers and designer to assume more flexible, supportive roles: responding to instructions, clarifying ambiguities, or procuring materials on request. Meanwhile, the workshop's designer, who had been accustomed to prescribing tasks, now found herself taking cues from the children's spontaneous ideas. On more than one occasion, a child would turn to the designer and say, "*Do you have anything else for materials*?" as though expecting the designer to serve as resource manager rather than creative lead.

An illuminating example of this fluidity unfolded when two children, uncertain how best to affix their carefully selected embellishments, successfully enlisted their teacher's help with the nitty-gritty of tying knots. Rather than dictating how the adornment should look, the teacher followed their instructions precisely: "*Tighter here, please*," or "*Pull gently so it's not crooked*!" Both the designer and teacher laughed at the reversal: the teacher's hands were skilful, but her input was secondary to the children's evolving vision. In that moment, the children effectively commandeered the teacher's expertise to realise an imagined design that they themselves authored.

8.3 Workshop 2, Underwater World

Building on lessons from Workshop 1, Workshop 2 shifted from teacher-allocated sub-tasks to a more open brief to better support children's imaginative expression and personal meaning-making of the *ocean* concept. The design task was to co-construct a shared underwater world scene while allowing each child to create and contribute their own elements (e.g., specific sea creatures, textures, and environmental features). The pedagogical aims were twofold: (1) to cultivate conceptual understanding of the ocean through multisensory exploration and collaborative composition, and (2) to encourage self-expression within a coordinated group outcome.

At the start of the session, teachers introduced the activity using an audio-supported briefing and a short familiarisation phase in which children oriented to the room, explored the available materials through touch, and practised safe movement among workstations. As in Methodology (see Table 4.9 for the outline of Workshop 2), the session proceeded through three main phases—exploration, making, and reflection—each punctuated by concise prompts (see Appendix F). Children first worked individually to design and make their chosen ocean elements, then moved into a collaborative assembly in which they positioned their pieces into a shared scene on a large base surface. Peer-to-peer talk was encouraged during co-design so that placement and composition decisions were negotiated rather than directed. Quick "show-and-tell" moments enabled children to describe features (form, texture, imagined behaviour) of their contributions before integrating them into the collective work. This sequencing preserved individual authorship while making interdependence visible in the final artefact.

Prior to the workshop, designer and teachers collaboratively refined the theme, selected/organised materials, and prepared an exemplar ocean model to illustrate possibilities without prescribing outcomes. Student profile information (see Appendix G) informed adjustments to material choices and workstation setup. During the workshop, designer facilitated material access, documented processes (fieldnotes and photographs of intermediate stages). Teachers acted as lead facilitators and timekeepers, introducing task goals, maintaining session pace, coordinating space and material circulation, and mediating communication with guardians. During making, teachers offered just-in-time pedagogical support (e.g., relating children's ideas to ocean concepts and vocabulary). During co-design, they supported turn-taking and co-ordination, and subsequently led a brief reflective discussion focusing on what was learned about oceans and about working together. Guardians were briefed in advance to provide on-demand assistance for personal care, orientation, or safety, and to refrain from aesthetic or design decision making unless explicitly requested by the child. Where over assistance emerged (e.g., adults attempting to "finish" a child's work), facilitator reiterated the "help-if-asked" guideline and redirected support to scaffolding exploration (locating tools/materials) rather than shaping outcomes.

In planning the second workshop, the Underwater World (Figure 8.5), we drew liberally on the insights gained from the Dragon session to streamline both logistics and design. From the outset, we determined that potential hazards would be minimised: scissors and other sharp objects were quietly removed from circulation, a decision influenced by safety concerns that had emerged in Workshop 1. We also chose the institution as the venue—one that both the teacher and I knew intimately. A second lesson from the earlier workshop emerged in our choice of materials. This time, we assembled objects that more concretely aligned with the aquatic theme. The same "kit of materials" is prepared for each child. Instead of a dizzying array of textures, we selected just a handful: real sand, seashells in varying shapes, and small stones reminiscent of a beachscape. Guardians and VIC alike seemed delighted by the tactile authenticity of these items: one child, upon touching the coarse sand for the first time, broke into a grin, exclaiming with surprise, "*This feels like a vacation at the seaside*!: Meanwhile, another child, enamoured of a smooth, pearlescent shell, asked repeatedly whether it "*really came from the ocean*."

Figure 8.5. Guardians check the children's materials and progress.

At a conceptual level, the Underwater World theme broadened the possibilities for narrative and sensory interplay. Children wondered aloud what sea creatures might inhabit the deep ocean, with questions like, "*Does a jellyfish feel like this squishy lump of clay*?" or "*Can you mix shells with sand to make fish scales*?" The teacher, meanwhile, deftly integrated small lessons into these fantasies, casually sharing bits of science—how real starfish move, how certain shells protect sea creatures.

Crucially, the second workshop also benefitted from a smaller, more focused team. Only a single teacher and I functioned as facilitators, and, having learned from the first workshop, we had already established a well-orchestrated division of labour. The teacher assumed the role of quiet mediator, confirming if a child needed more time or a break, while I concentrated on offering minimal but timely support, such as fetching additional shells or gently suggesting how sand could be molded into simple shapes.

8.3.1 Materials: Pink, Beach and Freedom

The absence of vision can broaden one's horizon. VIC may have more room for thought, unencumbered by visual conventions. Sighted children might be distracted or affected by the colour and materials used in existing artworks. A 12-year-old child described her work (Figure 8.6), "*The sea is supposed to be pink, and pink is soft. I'm not quite sure what's in the sea, but I think it's very warm and connected. I may not be able to draw it, so I'll just use colours to express it*." VIC can understand the concept of colour. The colours are associated with objects, experiences, and emotions rather than direct visual perception. They express colour like, "*Do I use yellow like autumn or yellow like a banana*?" Colours seem alive to them, imbued with personal meaning and tactile qualities. Paul Gauguin's Riders on the Beach II is noted for its masterful use of colour, particularly the pink-hued beach that dominates the composition. However, the pink envisioned by VIC is not influenced by Post-Impressionist techniques, Cennino Cennini's use of pink for glowing undertones in religious figures, or the Rococo movement celebrated the lush exuberance of pink. For them, pink is simply the pink of the sea.

Figure 8.6. A visually impaired child makes a pink underwater world.

Some stacked seashells in shapes reminiscent of fantastical towers, claiming they heard echoes of “soft breezes” or “distant songs” within these improvised structures. Another child delighted in hand scoops of sand onto a small patch of clay, then running his fingers through the gritty mixture—creating a makeshift “beach” where tiny plastic fish seemingly roamed free. Each of these designs refused to submit to a strictly visual canon; the materials were molded instead by intangible states of mind: comfort, curiosity, and a desire for imaginative visualisation.

8.3.2 Subject: Exemplar

The teacher created a example for this workshop (Figure 8.7). However, in a twist both telling and heartening, not a single child tried to replicate it. Indeed, some guardians referred to the sample for ideas, but the children themselves rarely ask for touch. There was a brief interlude further underscored this spirit of freeform creation.

She began by drawing a lamp and requested red, yellow, blue, and green paints. She explained that she was going to paint a party on a large lawn, stating, "*I'm going to paint the bottom half of the paper in green*." Each time she added a small part to the picture, she checked with me to ensure she had used the colours correctly and had drawn in the right place. Covering the entire paper seemed challenging, and inevitably, some areas had repeated colours. For visually impaired children, paintings are often created from parts to the whole, whereas sighted individuals can grasp the overall layout first. Her painting might appear unbalanced to us, with more colours concentrated on the right-hand side. However, she was unconcerned about this; she simply ensured that she included all the elements she wanted to express without leaving anything out.

Figure 8.7. Teacher-made underwater world example.

This vignette aligns with a broader observation: many of the workshop's VIC approached creativity from the inside out, guided by an idea to include every essential feeling or idea, rather than to conform to predetermined aesthetic forms. Their aim was not to master perspective, nor to prove how different or "gifted" they were; it was to share the experience of creating. And so, it hardly mattered if a painting appeared asymmetrical or if certain hues collided. In their eyes, they had told the story they wanted to tell. The teacher's exemplar—perfect as it was—merely hovered in the background, a polite suggestion of possibilities. Each child remained firmly at the helm of their own design trajectory, shaping their Underwater World.

8.3.3 Object: My Imaginary Underwater World

When asked what he liked most about the ocean, one child shrugged and answered simply, "*I don't know... I've never been*." Yet, despite never having experienced the sea, he proceeded to create a piece brimming with sensorial intrigue. Rather than drawing upon conventional imagery of coral reefs or fish, he covered a large section of the working surface with soft clay (Figure 8.8). No pretense of shaping graceful waves or recognizable shapes: he just spread the clay into a broad, undulating layer, declaring he liked the "feel" of its soft resistance beneath his hands.

Figure 8.8. A child just wants to spread the whole surface with clay.

Figure 8.9. The little fish with lots of eyes.

Another child wanted to craft a fish with “lots of eyes” (Figure 8.9). He had no direct reference for how many eyes a fish should have. In his imaginative world, multiple eyes simply meant seeing in multiple directions—perhaps a testament to the quiet wish that an unseen realm might hold infinite wonders. Cotton served as a proxy for “soft things,” for the airy hush of waves or the gentle buoyancy of floating seagrass. He patted tufts of it around the edges of his creation, remarking, “*I’ve never really touched the sea, but I think this is what it would feel like*.”

Rather than rely on visual references, they seize upon textures, shapes, and sensations that feel right. The ocean ceased to be a distant place they’d never visited and instead became a testament to their personal sense of wonder—an “underwater world” shaped entirely by their own imaginative instincts. When children respond to the question “*What’s special about the sea*?” with “*I used lots of cotton; I like the feeling*,” they transcend the idea that learning must adhere to reality. For them, the sea might be soft and cloudlike, or it might birth fish with many eyes.

8.3.4 Rules: Painting as Body

From a purely material standpoint, a painting consists of three elements: the frame, the canvas, and the pigments. In this view, painting is less about faithfully reproducing an image than it is about the corporeal interplay of these three components—a “body” onto which colour, texture, and motion can be enacted. For VIC, this perspective can be particularly liberating. They are free to explore the tactile substance of paint and brushstrokes, unconstrained by the assumption that each mark must coalesce into a coherent “picture.” Instead, their creative focus rests on the physical act of painting—the feel of the bristles, the flow of paint across the canvas, and the moment-to-moment decisions that emerge with each stroke.

In videos of VIC creating, one often sees a kind of “stuttering” approach, where the brush lingers in the same spot, uncertain when or where to move next. Some guardians, upon witnessing this seemingly hesitant process, interpret creating as especially challenging for their children. The repeated overpainting of one particular area, sudden pauses, and the occasionally erratic shifts from one region of the canvas to another resemble the patterns of a speaker who momentarily stammers, grasping at multiple possibilities before settling on the next phrase that defies the usual rules of linear progression.

Such irregularities can make the final composition difficult to decipher at a single glance—though that difficulty may matter little to the child. Yet a few guardians, worried about their child's "progress" or the design's overall appearance, occasionally step in and take over, hoping to impose a more recognisable form. This intervention, however well-intentioned, can inadvertently eclipse the child's own emergent logic. Actually, when rules are restored to their fundamental essence, each visually impaired child who fully participates in the activity can discover their own creative path.

8.3.5 Community: Friendship and Quiet

In this workshop, along with a tacit understanding between the teacher and designer, fostered a sense of belonging that neither demanded fanfare nor depended on continuous chatter. The teacher and I (the designer) discovered that weeks of planning were less important than our wordless awareness of each other's next step: handing over new materials without request, or quietly stepping in to help a child. This seamless rapport might easily go unnoticed—casual onlookers would see us moving around the room, occasionally pausing to confer in low tones—but it was crucial to sustaining an atmosphere that allowed VIC to remain at ease in their creative explorations.

Likewise, the children's friendships silently wove them into a cohesive group. One child, for instance, insisted on sitting beside a familiar friend throughout the workshop; she offered almost no commentary of her own yet seemed fully content to feel the friend's proximity. Though barely a word was exchanged, the trust emanating between them was palpable. If the friend exclaimed at a newly discovered texture or quietly giggled over a design mishap, that moment seemed equally meaningful for both. Sometimes, the mere presence of a peer—someone who knows you without prying—provides a sense of refuge that transcends the need for overt conversation.

8.3.6 Division of Labour: Watching, Wandering and Lingering

Some guardians and the teacher quietly standing or sitting beside the children, observing their evolving work without intruding. In a more traditional classroom, "watching" might be mistaken for passive supervision; but here, it helped maintain a reassuring presence that neither dictated nor interrupted. One parent, for instance, stationed herself at the edge of a table, eyes following her child's small forays with shells and sand. Although she rarely spoke, her watchful posture conveyed readiness to assist if the child encountered difficulty.

By contrast, wandering was more dynamic. During the busiest moments, the teacher and designer would roam around the room, responding to bursts of excitement or confusion—one child summoning us to ask about mixing seashells with clay, another beckoning for more cotton. VIC, too, occasionally wandered: one might leave her own station to peek (or rather, ask and touch) what a friend had made, gleaning new ideas in the process. Meanwhile, we carried bits of advice gleaned from the children's successes or struggles, reassembling the workshop's collective knowledge in real time.

Equally crucial was the figure of the lingerer—a participant who settled into one spot, sometimes for a good length of time, poring over details or perfecting a texture. One child in particular spent nearly half the workshop smoothing a mound of clay into an ever more seamless surface. For him, the pleasure lay in the repeated act itself, rather than in any progress toward a "finished" ocean scene. Now and then, a teacher or peer would check in: "*Is it done*?" The child only shook his head, content to keep refining.

This patient lingering illustrated that division of labour does not always revolve around discrete tasks. Instead, each participant's chosen mode—prolonged immersion, watchful presence, or wandering facilitation—coexisted harmoniously, fulfilling the community's shared goal of nurturing the children's self-directed creativity.

Taken together, watching offered gentle vigilance; wandering seeded ideas and connected pockets of activity; lingering demonstrated that creative work sometimes unfolds through deep, unhurried engagement with a single material or idea. Far from being hierarchical or prescriptive, this division of labour recognised every individual's freedom to move, observe, and create at a pace and style conducive to their own sense of discovery.

8.4 Key Features

As noted in Chapter 3, the third generation of CHAT has been relevant to understanding and explaining the evolution of activity in a cultural and historical context. Therefore, I have applied it to a dynamic design environment that is in a constant and rapid process of change. Building upon the rich, empirical data from the co-design workshops, this section synthesises the essential features that characterise co-design processes involving VIC. As discussed, the co-design practice is not a straightforward technical method but a deeply relational, sensitive, and adaptable process. It draws heavily on the lived experiences, sensory explorations, and collaborative energies of VIC, reshaping creative labour into a collective educational journey. Specifically, the process unfolded through six defining features (Table 8.1): (1) roles shifts, (2) sociomateriality, (3) generativity, (4) divergence, (5) self-reliance, and (6) fluid hierarchies.

Table 8.1. Features of the co-design process involving VIC.

Features	**Description**
Role Shifts	Traditional adult-child power dynamics dissolve, enabling VIC to lead creative decisions while adults adopt supportive roles; expertise flows

	bidirectionally, prioritising immediate needs over fixed roles
Sociomateriality	The process emphasises the interplay between social interactions and material engagement that shaped the co-design process at every turn
Generativity	An open-ended, playful approach that values exploration and spontaneous idea generation over rigid, outcome-driven goals
Divergence	The acceptance of design outcomes that depart from conventional visual norms or adult-defined standards of correctness
Self-reliance	VIC are empowered to make their own design decisions and manipulate materials independently, seeking help only when truly necessary
Fluid Hierarchies	A collaborative mode in which VIC, teachers, guardians, designer and materials function on near-equal footing, exchanging ideas and resources without rigid top-down instruction

8.4.1 Role Shifts

From the outset of these co-design workshops, the participants—teachers, designer, guardians, and VIC—appeared to occupy clearly delineated roles. Teachers were expected to lead instruction, the designer to orchestrate activities, and children to receive guidance and give feedback. However, as the sessions evolved, those initial partitions proved remarkably permeable. By the midpoint of the workshop, children increasingly called the shots: "*Move this button here*," "*Let's add feathers to decoration*," and "*No, I don't need help yet*!" Meanwhile, teachers took on tasks once assumed to belong exclusively to the children, such as tying knots exactly as instructed by children. Guardians who had arrived as mere onlookers found themselves offering practical interventions—fetching materials at a child's request or quietly suggesting new textures. The shift of "teacher as instructor" toward "teacher as resource" empowered the children to articulate their desires more forcefully. Over time, they developed the vocabulary to solicit exactly what they needed—be it fresh clay, a different colour of paint, or the correct technique to secure a seashell. Teachers, designer, and guardians, meanwhile, learned to tune their observational lens to the children's signals, intervening only when asked or when a child's frustration visibly mounted.

Equally noteworthy was how guardians, previously believing they would simply "assist," demonstrated forms of local expertise essential to the design process. Some parents, for instance, had knowledge of their child's tactile preferences, gleaned from everyday domestic routines—information that teachers and designers lacked. Their suggestions—"*He doesn't like anything prickly, maybe a softer material is better*"—came to inform the children's next steps. Consequently, the guardian's role no longer resembled passive supervision; rather, they became interim experts, seamlessly sharing specialised knowledge and responding to emerging challenges.

Collectively, these shifts highlight the notion that role assignment in co-design involving VIC is never permanent; it fluctuates in response to the participants' evolving confidence, curiosity, and situational demands. The VIC's willingness to experiment prompted them to adopt new responsibilities, while adults embraced supportive or consultative positions, aware that relinquishing control could elevate the children's voices. In effect, the culture of reciprocity—I guide you here, you guide me there—came to define the social atmosphere of the workshops. Rather than fixating on top-down or bottom-up structures, participants learned to read each other's cues, negotiating who would act, assist, or lead at any given moment.

8.4.2 Sociomateriality

A defining characteristic of these co-design workshops was the deeply relational way that people and materials shaped each other's actions, a phenomenon best understood through the lens of sociomateriality. Materials refer to the objects used in the co-design process, such as sand, plastic strips, clay, and other tactile items. Sociality refers to the network of social relationships and interactions that emerge during the co-design process. The features of sociomateriality means 1) shift from what materials can do to what materials and people can co-produce; 2) prioritising relations over actors, whether they be social or material; 3) view social and material actors not as discrete entities with predetermined qualities but as emerging relations performed in co-design (Rong & Hansopaheluwakan Edward, 2025).

Throughout the workshops, the children's first response to material was often to interrogate its tactile properties and possibilities. One child, for instance, pushed handfuls of sand through her fingers until she discovered she could press the grains into a mound that resembled a small dune. "*It feels a bit like a beach*," she mused, promptly deciding this "beach" must occupy the centre of her undersea design. The sand did not merely "help" her achieve a predetermined vision; rather, the sand's texture and behaviour provoked her to imagine a coastal environment. In this way, the material co-authored her creation, directing her aesthetic choices as much as (or even more than) her own preconceived ideas.

Though children explored materials with an individual sense of curiosity, their interactions were also socially mediated. For instance, when a guardian noticed a child was reluctant to touch a coarser, scratchy surface, she suggested substituting a softer fabric scrap from her bag—an informal, unplanned artifact that turned into a piece of an undersea "blanket." Meanwhile, the teacher facilitated children reflections—"*How does this shell feel different from that one*?"—so that VIC developed shared vocabularies for describing texture and weight. This collective dimension illustrates how sociomaterial ties crisscrossed individual design process; a single child's discovery (e.g., the resonance of a hollow shell) swiftly traveled through the workshop, prompting others to examine their shells differently or incorporate hollow spaces into their work.

Critically, the final results were co-constituted by these entangled human–material relationships. Objects did not merely serve as props, nor did children simply impose designs onto passive substrates. Instead, materials invited exploration, children experimented, and teachers/designer responded—all in a cyclical process. For co-design facilitators, this underscores the importance of offering materials flexible enough to prompt discovery, while staying receptive to how children might reinvent these materials' purpose. In practical terms, teachers might introduce a variety of textures, shapes, or sounds, then stand back to observe how children negotiate meaning, re-define the objects, and in turn, shape each other's creative directions.

8.4.3 Generativity

Perhaps more than any other feature, generativity reveals the spontaneous, exploratory nature of the co-design process—particularly when working with VIC. Rather than rigidly adhering to a pre-scripted lesson or template, the workshops embraced an environment where unplanned ideas, improvised solutions, and ongoing revision became the norm.

One of the most telling indicators of generativity was the frequency with which children abandoned initial plans. A child might start by sculpting a mound of clay to represent a fish, only to abruptly decide it felt more like "sea grass" after accidentally poking shallow indentations into its surface. Such decisions were neither mistakes nor distractions; they were catalysts. By following these tangential impulses, children discovered uncharted design directions that even the teacher or designer could not have anticipated. Rather than working toward a polished final product, the children pursued a process in which every step—whether success, misstep, or sidetrack—provided material for further exploration. Put differently, each child's creation was always in flux: an evolving prototype whose ultimate form depended on what the material "suggested" at any given moment.

A further hallmark of generativity involved the subversion of fixed endpoints. Instead of concluding a piece was "done," several children persisted in refining or outright reimagining their projects until time or physical fatigue intervened. Here, open-endedness reigned: children could always add, remove, or rearrange elements, unburdened by demands for aesthetic consistency or adult notions of completion. Therefore, emphasising generativity in co-design refocuses creative activity on the immediacy of discovery, rather than a pursuit of polished artifacts. For VIC, this shift is especially beneficial because it allows them to embrace sensory-driven experimentation without fear of "ruining" a set plan or deviating from a rigid curriculum. Teachers and designer, in turn, learn to present a diversity of materials and intangible prompts—textures, sounds, mini-stories—then step back, trusting that children's instincts will yield surprising routes.

8.4.4 Divergent

A fourth characteristic emerging from these workshops is divergence—the tendency for VIC's design choices to depart strikingly from conventional or adult-centric norms, particularly as they rely on their own sensory and imaginative cues rather than visual references. Divergence here does not simply mean "unusual" or "incorrect"; rather, it signifies the children's capacity to merge everyday sensations, stray observations, and personal associations into forms and narratives that hold compelling internal logic for the children themselves.

A telling illustration of divergence appeared during second workshop, where a child decided that her "sea water" needed to be made of layered scraps of smooth fabric rather than paint. "*Real water isn't rough*," she declared, insisting that she liked the way the fabric draped. Though the teacher offered to help her incorporate different textures of fabric for "waves," the child declined, explaining that her ocean should feel "gentle and calm." In a conventional art lesson, an adult might have insisted on depicting waves through outlines or shading; here, the child's tactile sense of "soft" water completely upended visual metaphors.

Divergent thinking in the workshops did not exist in isolation; it influenced the broader collective process. Once one child confidently works from an unconventional angle, such as sticking a feather on a dragon to represent a "flying dragon", other children will venture out to explore equally unconventional patterns. The acceptance of each child's outlandish vision created a chain reaction, prompting others to adopt or adapt similarly nontraditional approaches. In effect, divergence became contagious: as soon as one child saw a peer's radical idea legitimised by peers and facilitators alike, further experimentation seemed natural, even joyful.

8.4.5 Self-reliance

Rather than waiting for continual direction from adults, many VIC displayed a marked preference for taking the lead themselves—resolving setbacks, experimenting with novel materials, and pursuing design ideas even when no immediate solution was in sight. At times, a teacher might be assisting another child, only to turn around and discover a child had already moved on to incorporate an extra piece of fabric or a tactile sticker from the materials table. While some children announced their ideas aloud, others quietly tested and revised their work, making minimal fuss over whether an attempt was "right" or "wrong." But, self-reliance within co-design did not mean children refused help categorically. Instead, they often chose when to accept guidance. If confronted with a tool too complex, they would request support—and typically only as much as was strictly necessary.

In cultivating self-reliance, the workshops advanced a key educational objective: empowering VIC to trust their own capabilities in contexts that go well beyond designing an art piece. By letting children navigate uncertainties, adapt materials to their needs, and chart their own creative directions, the co-design process effectively modeled an approach to learning that prises autonomy. Teachers and designer, meanwhile, learned to calibrate their involvement—stepping back unless explicitly requested, thereby allowing children to discover the satisfactions (and frustrations) of independent creation.

8.4.6 Fluid Hierarchies

Among the most arresting qualities of the co-design process was the dissolution of predetermined ranks or hierarchies. Conventional distinctions—teacher as master, child as novice, designer as expert—inevitably softened until all participants found themselves cycling through unexpected roles, however briefly. This dynamic did not emerge from an explicit rule or workshop guideline; rather, it unfurled organically in response to the children's inventive evolve.

Such fluidity also allowed for bursts of creative leadership from unexpected quarters. Some children undertook a spontaneous "audit" of the materials table, insisting that certain feathers and plastic beads needed rearranging for better access. The teacher, initially standing at the periphery, was summoned by a child's self-assured, "*I think you should place those buttons in pairs*." Acquiescing without hesitation, the teacher quickly taking direction as though the children's verdict was a blueprint. At a later juncture, when the parent began to suggest a "correct" layout, it was the child who offered a gentle refusal, averring, "*I like it this way*." The mutual respect in this exchange—where each party could propose or demur without forfeiting legitimacy—embodied the synergy that made co-design possible.

Ultimately, "fluid hierarchies" manifested as a form of collective improvisation, reminiscent of an ensemble performance in which each musician takes a turn at improvising a melody. Far from any top-down orchestration, every participant claimed moments of authority or influence, only to cede them gracefully as another voice rose. This also underscores the pedagogical potency of co-design. By dismantling static power structures, the children acquired the license to shape their own experiences, while teachers and designer expanded their repertoire of supportive roles. In doing so, the VIC as a whole achieved a more elastic, co-creative ethos—one in which each contribution, no matter how small or fleeting, could resonate across the entire shared space of making.

8.5 Chapter Summary

The notion that co-design is a communicative process and a complex and dynamic activity system that intertwines subjects (people), object(s), materials, rules, community, and division of labour, as suggested by the CHAT framed this chapter. By situating VIC as active co-designers, this chapter reveals co-design as a deeply relational and context-sensitive practice that reconceptualises creative labour, emphasising sensorial engagement, experiential knowledge, and meaningful interaction. Through the co-design workshops, six defining features emerged clearly: role shifts, sociomateriality, generativity, self-reliance, divergence, and fluid hierarchies. These elements collectively facilitated a transformation in attitudes, expectations, and relationships among VIC, teachers, designers, and guardians. Ultimately, the true power of co-design lies not simply in material outcomes, but in its ability to fundamentally reconfigure relationships, amplify children's voices, and cultivate collaborative knowledge-making environments. The next chapter discusses the results gathered from this study.

9. Discussion

This chapter brings together the entire thesis, synthesising the findings from Chapters 5 through 8 into a critical discussion aimed at addressing the central research questions. These findings are examined in relation to the existing literature and interpreted through the lens of the chosen theoretical framework and conceptual constructs.

This chapter is from an article under review:
Rong, A. & Hansopaheluwakan-Edward, N. (2025). Co-design as Pedagogy: Understanding Materiality, Designed Form and Learning Activity with/for Visually Impaired Children. *Co-design*.

9.1 Introduction

In Chapter 2 of this thesis, I identified numerous challenges confronting designers and educators—such as limited time, expertise, and practical knowledge—that critically influence decision-making processes. Despite a growing interest in co-design, studies examining in-situ design practices with VIC and the decision-making processes of key actors, particularly within educational contexts, remain scarce. Given these premises, this study departs from an approach focused solely on end learning products, offering insights that empower designers and educators to rethink the creation of educational experiences and to recognise children—especially those with disabilities—as active participants in shaping their own learning journeys.

This chapter discusses the key findings presented in Chapters 5 through 8 and situates them within the broader context of the literature reviewed in Chapter 2. The discussion is structured around four interrelated themes that necessarily intersect, reflecting the study's systemic focus on the reciprocal relationships among processes, actors, communities, rules, and mediating artefacts—rather than isolating a fixed checklist of factors that ensure or hinder success in co-design for VIC learning.

Mirroring the logic of the results chapters, Section 9.2 advocates for the multivoiced nature of VIC learning design by examining specific sociocognitive and materially mediated processes engaged by study participants, and by exploring the role of teachers and the influence of contextual factors on design decisions. Section 9.3 then moves on to critically debate how materials are conceptualised and manifested in learning activities. Section 9.4 synthesises and concretises the impact of pedagogical frameworks, VIC's experiential knowledge, and material possibilities on designer's professional practice. Section 9.5 closes the loop by providing a detailed account of the areas of growth and practice advancements observed in VIC, thereby affirming the symbiotic relationship between co-design and VIC learning. The chapter closes with additional reflections on these insights (Section 9.6).

9.2 Multi-voicedness in Co-design: Negotiating Boundaries among Materials, Actors, and Rules

9.2.1 Factors Affecting Design Decisions

Chapter 5 identified a range of influential factors at individual, team, community, societal, and institutional levels that shaped teachers' design decisions for (VIC in China. At the individual level, teachers' beliefs, experiences, and competencies critically informed their approaches to instructional design. Teachers often viewed themselves as adaptive problem-solvers who creatively modified resources based on their students' specific needs. This finding aligns with Sheppard and Aldrich (2001), who emphasised the importance of teachers' experiential knowledge in guiding design decisions. While this experiential orientation frequently led teachers to resourceful improvisations—such as adapting everyday objects into tactile learning materials—it occasionally reinforced traditional methods, limiting exploration of newer educational technologies and methods. Indeed, several teachers reported hesitation in adopting unfamiliar technologies due to concerns regarding personal competence and technological reliability, highlighting the significant role of self-efficacy in pedagogical innovation (Kulviwat et al., 2014; Vongkulluksn et al., 2018).

Another critical individual factor was teachers' content knowledge and pedagogical competencies specific to visual impairment. Given that specialised skills such as TG creation and braille literacy are seldom included comprehensively in standard teacher education curricula in China, teachers frequently expressed feelings of inadequacy when faced with designing advanced TG or multi-sensory resources (Rosenblum et al., 2018). Such gaps in specialised knowledge often prompted reliance on simplistic or less effective pedagogical strategies, a challenge consistent with existing research indicating the necessity for targeted professional development (Hirsch, 2016; Rohrer & Pashler, 2010).

Furthermore, the issue of time constraints emerged as a significant and pervasive individual factor affecting teachers' design decisions. Teachers consistently highlighted the pressure from heavy administrative duties combined with regular teaching responsibilities, particularly within resource-constrained special education environments (Mukhiddinov & Kim, 2021). Consequently, despite recognising the potential educational benefits of elaborate or innovative materials, teachers frequently defaulted to minimal or pre-made solutions due to insufficient time for the development and testing of customised tactile or audio-based resources.

Team and institutional-level influences are often intertwined. At the team level, collaborative planning with peers and specialists can spark innovation, yet also reveal tensions in pedagogical beliefs or resource use (Carbonell et al., 2013). When teachers co-design materials for TG, their success often hinges on how openly expertise is shared among team members—such as administrators, experts, O&M specialists, or even general education teachers who might have minimal knowledge of visual impairment. In some cases, these collaborations result in highly creative, interdisciplinary approaches, where teachers pool their knowledge of local craft methods or digital tools to rapidly prototype tactile resources (Rule et al., 2011; Sat & Cagiltay, 2025). However, conflicting schedules, uneven workloads, or siloed institutional structures can impede collective design efforts and limit the scope of what teachers feel they can achieve (Hoover & Harder, 2015; Schroeder, 2023).

The discussion on community and social factors, notably peer and familial support, also profoundly impacted design decisions. The research underscored the substantial benefits of peer interactions and familial insights, particularly within China's collectivist culture, where community engagement and family involvement are integral to educational processes (Chen et al., 2009; Hofstede, 2011; Jellison et al., 2015). However, societal attitudes toward disability presented substantial barriers. Historically entrenched stigma and resulting social isolation continue to restrict access to inclusive education for VIC, posing challenges that teachers must continuously negotiate (Li et al., 2021; Qu, 2019). Also, institutional factors—such as policy frameworks, administrative support, and resource availability—played a critical role in shaping teachers' capacity for innovation. Although inclusive educational policies in China increasingly recognise the need for tailored supports for VIC, persistent budget constraints and stringent accountability standards often discourage experimentation with new educational materials (Engel & Weber, 2017).

9.2.2 Multi-voicedness Context

The guiding principle of multi-voicedness deepens our understanding of how design decisions emerge amid the various identified factors. As discussed in section 2.5.2, co-design inherently embraces multi-voicedness by integrating diverse forms of knowledge and competencies from both adults and children (Yip et al., 2017). The findings of this study confirm that participants brought their unique professional and personal backgrounds to the collaborative process, thereby enriching co-design while also exposing critical tensions. Co-design involving VIC further extends Engeström's (2001) assertion that each activity system comprises individuals from varied cultural and professional backgrounds—a diversity that becomes increasingly apparent as multiple systems intersect.

Multi-voicedness in co-design is fundamentally an acknowledgement and active integration of multiple perspectives, voices, and experiences within the co-design process. It emerges as a crucial dimension in co-design methodologies where the perspectives of VIC, designers, educators, and other stakeholders intersect to generate enriched, more inclusive design solutions. The researchers have highlighted that co-design in educational contexts necessitates the integration of diverse voices to truly support inclusive education (Florian & Black-Hawkins, 2011; Johansson-Sköldberg et al., 2013). The research findings explicitly illustrate multi-voicedness through different chapters. For example, Chapter 5 illustrates how teachers integrate their pedagogical expertise with the tacit knowledge about VIC's capabilities and preferences, often creatively adjusting the design to address specific classroom needs. Teachers, through their situated pedagogical choices, become crucial designers of the design process, dynamically balancing institutional constraints, curricular requirements, and children's experiential needs. This multi-layered decision-making showcases multi-voicedness in action, where co-design practices are never singular but rather dialogic (Manzini, 2016), responsive (Thorpe & Gamman, 2011), and adaptive (Baibarac & Petrescu, 2019).

Moreover, Chapter 6 and 7 advances this point by positioning designers explicitly as negotiators among various activity systems—balancing demands, mediating power dynamics, and ensuring equitable participation. Effective communication is a well-established theme in co-design research (Butler et al., 2022; Brown et al., 2022; Garcia-Melgar et al., 2022). The present findings extend this narrative by emphasising how social inclusion influences communication dynamics. Subtle, often overlooked prejudices can insidiously impact the co-design process, marginalising valuable perspectives (Fletcher, 2024). Importantly, the challenge of communication extends beyond content and clarity to include the methods and materials employed to convey information—factors that are particularly vital for VIC, whose interactions differ markedly from those of sighted peers (Webster & Roe, 1998). In this study, multi-voicedness encompasses not only human stakeholders but also the material and cultural artifacts involved in learning activities. The findings support the perspective of Sørensen (2009), reinforcing that materials are active co-constructors of the learning and design experience, carrying their own voice into the dialogue of co-design processes. This necessity is further underscored by research on multimodal communication (Cavazos Quero et al., 2021), which advocates for the use of diverse communication methods. Therefore, effective communication in this context transcends verbal exchanges, incorporating material aspects that enrich the co-design process. As designers negotiate these various elements, they ensure that the voice of each stakeholder, including materials, is fairly represented and considered in design decisions.

Chapter 8 provides critical empirical support to the principle of multi-voicedness by explicitly engaging VIC as active co-designers. By actively participating, children articulated their perspectives, needs, and preferences, challenging adult preconceptions and traditional hierarchies (Clark, 2011). Thus, multi-voicedness, as shown in the study, facilitates the negotiation of meaning among participants and leads to designs that are more relevant, culturally sensitive, and effective for supporting learning activities.

9.2.3 Negotiating Boundaries

Negotiating boundaries in co-design is fundamentally an act of navigating and reconciling distinct yet interconnected roles, expertise, and knowledge systems. Drawing upon Kleinsmann and Valkenburg’s (2008) characterisation, co-design requires actors from diverse disciplines to continuously negotiate their knowledge about both the design process and the design content towards a shared understanding and goal. The present study extends this discourse by detailing the nuanced interactions among teachers, designer, materials, and VIC, highlighting the reciprocal nature of boundary negotiation where roles are not fixed but rather dynamically reconstituted.

Furthermore, the negotiation of boundaries within my research underscores the critical role of materials as active agents or protagonists, echoing Ingold's (2012) concept of materials as dynamic constituents rather than passive recipients of human agency. Consistent with Sørensen's (2009) post-humanist critique of traditional educational research, my study argues that negotiating boundaries necessarily involves engaging with the socio-material aspects of design activities. The material qualities and affordances—textures, forms, tactile richness, and interactive potentialities—continuously shape the participatory dynamics, redefining the boundaries between learner, material, and educator. Such negotiations move beyond traditional utilitarian perspectives where materials are passive instruments; instead, materials become integral partners in the co-design process, influencing how design solutions emerge and are validated in practice.

Consistent with findings by Sanders and Stappers (2008), who advocate for recognising the transformative potential of co-design in redefining who designs and how design is performed, my empirical findings (particularly in Chapter 7) reveal how designers adopt multiple roles—mediators, facilitators, and critical listeners—actively managing the interplay among different knowledge domains. The study finds that designer, rather than imposing design solutions directly, often engage in subtle but powerful forms of boundary negotiation that elicit and reconcile the tacit knowledge held by teachers, the experiential insights of VIC, and the capacities and affordances of learning materials. Thus, designers foster a co-design mindset among participants, guiding teachers toward greater self-awareness of design potentials and limitations.

Another critical dimension revealed in my study pertains to the negotiation of power relationships and participation rights within co-design activities involving VIC. Theoretical contributions by Raman and French (2022) underscore participation as a critical aspect of empowerment, yet my findings in Chapter 8 further nuance this by identifying how boundary negotiations actively involve children in decision-making processes. This expands the conventional notions of child participation, which typically limit children's contributions to initial ideas or superficial input, rather than substantive influence over design decisions. My analysis details how children negotiate boundaries of participation, establishing their roles not merely as beneficiaries or users but as genuine collaborators and knowledge producers. These interactions resonate deeply with Freire's (1970) emancipatory pedagogy, suggesting that the negotiation of boundaries in co-design not only enhances the material design outcomes but actively promotes VIC agency, autonomy, and learning.

Moreover, boundary negotiation identified in my findings relates to the dialectics of structure and agency in co-design practices. Literature from Sørensen (2009) and Shove et al. (2012) argues against reductionist views of agency and structure as binary oppositions, advocating for an approach to social practice that emphasises the ongoing, relational interactions among competence, meaning, and materials. In line with this, this study highlights the importance of navigating boundaries between the designed intentions ("design in advance") and improvisational responsiveness, described by Dillenbourg (2013) as "design for orchestration". Negotiating these boundaries involves recognising how fixed instructional plans, flexible pedagogical interventions, and emergent material affordances jointly contribute to shaping the collective learning experiences of VIC.

Lastly, the research advances our understanding of negotiating boundaries within the specific socio-cultural and institutional contexts of China, bridging a critical gap highlighted by Magnusson et al. (2017), who have noted a dearth of culturally sensitive empirical research in co-design with visual impairment. My findings reveal how cultural expectations and institutional frameworks significantly shape the boundaries of what is possible or permissible in co-design processes. Through carefully orchestrated interventions informed by CHAT, my study underscores the importance of critically examining these cultural constraints and affordances. It points toward culturally specific strategies that designers and educators might employ to overcome systemic challenges, such as resource constraints and hierarchical relationships, by redefining boundaries in ways that enhance inclusion and collective learning.

9.2.4 Sociomaterial Disconnect and Accessibility

Sociomaterial disconnect refers to the gap or disjunction that arises when the interactions between social (human actors) and material (tools, artifacts, and technologies) elements do not effectively support the intended outcomes of an activity—in this context, accessibility in educational environments for VIC. Accessibility, particularly through tactile feedback and auditory enhancement, has been identified as a key factor in co-design, aligning with earlier research on the importance of multisensory approaches in design (Lloyd-Esenkaya et al., 2020). The findings supports these perspectives and extends the discourse by suggesting that tactile misunderstandings and the use of inaccessible materials signify more than just a lack of appropriate tools. Although these insights are not entirely new, they rarely surface in co-design research involving individuals with disabilities, especially in design research centred on CwD. Accordingly, I advocate for greater awareness of research on factors influencing accessibility in the co-design process and vice versa.

A critical aspect identified by Sørensen (2009) and echoed throughout my findings is the interdependence between material properties and social practices. Educational materials designed without sufficient consideration of the tactile needs and cognitive engagement capacities of VIC often lead to ineffective learning experiences. ndeed, while tactile feedback and auditory enhancements are not exclusive to VIC, they have significant relevance to co-design processes for individuals with different sensory or cognitive disabilities. For instance, digital storytelling activities using smart tangibles have provided structured, interactive, and engaging environments for children with autism spectrum disorder (ASD), supporting them with visual feedback (Guneysu et al., 2024). Similarly, Cavdir (2022) details how vibrotactile wearable interfaces can foster improved sound and music perception among deaf dancers through co-design sessions. This situation calls for recognition of the agency of both social and material actors in the design process and their combined influence on the success of co-design initiatives, especially in co-design practices involving different disabilities.

The sociomaterial disconnect manifests significantly in how materials are integrated within pedagogical practices. My study identifies that while teachers often possess robust pedagogical knowledge, their material design capabilities tend to be limited by institutional constraints such as insufficient resources, lack of training, and limited collaboration with designers. This finding resonates with the research on pedagogical design capacity (Herbel-Eisenmann et al., 2009), indicating that the ability to effectively orchestrate materials within learning activities remains a significant challenge for educators working with VIC. Some researchers highlight that tactile TG are frequently underutilised due to a misalignment between their material form and educational context (Sheppard & Aldrich, 2001; Engel & Weber, 2017). My observations further underscore the practical barriers teachers face in adapting materials, notably the excessive time and specialised knowledge required, which frequently results in simplified or inadequate materials that fail to meet the educational standards necessary for meaningful learning.

Further complicating this disconnect is the issue of power dynamics in the co-design process. My research corroborates previous findings by highlighting the dynamics negotiating roles among designers, teachers, and VIC (Rong & Hansopaheluwakan-Edward, 2025). In this dynamic, designers often function as mediators, balancing educational objectives set by teachers against the experiential needs expressed by children. When these negotiations are not handled effectively, the resultant designs may perpetuate accessibility gaps, further marginalising VIC within educational settings. Addressing sociomaterial disconnect necessitates expanding the concept of accessibility beyond mere physical usability to encompass cognitive and cultural dimensions. As workshops revealed that when VIC are actively involved in co-design processes, the sociomaterial arrangements become more aligned with their sensory and cognitive strengths, thereby enhancing their educational engagement. This co-creative involvement also fosters mutual learning: teachers and designer gain deeper insight into how VIC interact with audio-tactile resources, ultimately contributing to more inclusive and effective educational practices.

9.3 Embracing Contradictions and Historicity: Dynamic Mediations by Material Artifacts and Social Structures

Embracing multi-voicedness necessarily involves dealing with contradictions and tensions. As explained in section 3.5.2, Engeström and Sannino (2011) distinguish contradictions into four levels: primary (within a single element, e.g., rules containing competing values), secondary (between elements within a system, e.g., subject-tools misalignments), tertiary (between an emerging model of activity and a preceding one), and quaternary (between neighbouring activity systems). These tensions should be read historically, CHAT assumes that present practices sediment prior forms, such that contradictions both index and propel transformation over time . In this sense, working through contradictions is what drives expansive learning: participants re-mediate tools, rules and objects to produce qualitatively new ways of acting together (A fuller exposition appears in Chapter 3). The research corroborates this theoretical stance by illustrating how contradictions within co-design processes provoke teachers, designer, and VIC to re-examine traditional roles, pedagogical assumptions, and their relationships with material artifacts. From a design perspective, the findings demonstrate that effectively engaging with contradictions and historicity requires designers and educators to adopt flexible, reflexive stances—conceptually and practically reconciling diverse viewpoints and conflicting demands. This resonates with Shove et al.'s (2012) concept of social practice theory, in which competence, materials, and meanings dynamically co-evolve over time. Also, as illuminated by Florian and Black-Hawkins (2011), inclusive pedagogy demands a willingness to engage productively with difference and tension rather than seek to suppress them.

9.3.1 Primary Contradictions

A critical primary contradiction identified in this research emerged within the "rules" component of the activity system, particularly the tension between institutional quality assurance requirements and innovative pedagogical design strategies prioritising flexibility, creativity, and inclusion. Teachers regularly experienced friction when attempting to adopt pedagogical designs that diverged from institutionally prescribed guidelines, highlighting contradictions between compliance-driven institutional imperatives and the demand for personalised educational approaches. This contradiction became apparent presented in Chapters 5, where teachers were often constrained by rigid institutional assessment metrics that emphasised measurable outcomes over nuanced, VIC-centred pedagogical innovation. Teachers repeatedly faced dilemmas: on one hand, their professional identities as inclusive educators drove them to create accessible, engaging learning experiences; on the other hand, institutional guidelines demanded conformity and standardisation, implicitly discouraging experimentation and adaptive design practices. Such tensions resonate strongly with previous observations in the literature; Florian and Black-Hawkins (2011), for instance, argue that the requirement for educational standardisation frequently conflicts with the necessity for inclusivity and flexibility, resulting in compromised pedagogical decisions and diluted learning outcomes. This turn to enhanced flexibility and innovation has implications for inclusivity, reflected in both institutional policy discourse and critiques suggesting the exclusionary effects of flexibility (Benade, 2019).

Another prominent primary contradiction arose within the materials component of the activity system. Here, tactile learning materials intended for VIC presented inherent internal tensions between their conceptual purposes and practical implementation. While TG guidelines advocate precision and standardisation—such as clear tactile representations that align closely with visual counterparts (BANA, 2010)—teachers and designers consistently confronted practical challenges, including limited material resources, technological constraints, and insufficient production capacity (Chapter 5 and 7). For example, TG created through thermoforming or swell-paper technologies, although theoretically ideal for educational purposes, proved time-consuming and resource-intensive in practice, limiting their frequent and timely application in classroom activities (Gual et al., 2015; Mukhiddinov & Kim, 2021; Ramsamy-Iranah et al., 2016). This internal tension echoes findings from earlier studies, such as Sheppard and Aldrich (2001) and Rosenblum et al. (2018), who similarly emphasise how the complexity of TG production acts as a significant barrier, impeding their optimal usage. Thus, the primary contradiction within tactile artifacts lies in the disconnect between the designed potential of learning materials to enhance VIC independence and their demanding production processes, which practically inhibit consistent educational use.

A third significant internal contradiction highlighted by the present study concerns the “subject” component of the activity system, notably within teachers’ professional identities. TVIs are caught in the duality of their roles as both traditional educators and emergent designers, leading to internal tensions in their practice. Chapter 5 revealed teachers experiencing frequent uncertainty as they oscillated between established pedagogical routines and newly acquired responsibilities of design facilitators. Engaging in co-design introduced additional demands on TVIs to negotiate between their traditional disciplinary expertise, professional expectations, and emerging co-design methodologies. Although studies such as Brown and Beamish (2012) previously identified this complexity, the present research further deepens understanding by illustrating how these internal tensions manifest concretely in daily pedagogical decision-making, requiring teachers to continuously mediate between ingrained professional routines and innovative design responsibilities. Teachers often expressed discomfort at the perceived blurring of boundaries between traditional teaching tasks and the less familiar design-oriented engagements, thus confirming primary contradictions within the 'subject' component.

Primary contradictions were also visible within the broader "community" and "division of labour" elements, primarily reflecting how traditional hierarchical structures conflicted internally with emergent collaborative practices introduced through co-design methods. As detailed in Chapter 7, designer and teachers frequently encountered contradictions between the hierarchical roles traditionally imposed within educational settings—particularly in Chinese institutional contexts—and the participatory ethos central to co-design. Such tensions were especially pronounced when designer encouraged teachers and VIC to adopt more equitable and collaborative relationships, prompting reconsideration of deeply entrenched power dynamics and role expectations. This contradiction aligns with existing critiques by scholars such as Gale (2012) and Sørensen (2009), who highlight similar tensions in transitioning toward democratic and inclusive pedagogies within historically hierarchical institutions. Importantly, findings from this study suggest that, although initially destabilising, embracing these tensions productively reconfigures institutional practices and professional relationships over time.

9.3.2 Secondary Contradictions

Unlike primary contradictions, which arise internally within single elements, secondary contradictions reflect tensions emerging through interactions across multiple components, such as between subjects, objects, rules, and the community. A key secondary contradiction highlighted in this research lies between the components of subjects (teachers and designers) and the tools (learning materials and tactile graphics) employed within the co-design processes. Specifically, the empirical data collected during observations and co-design workshops reveal that while tactile materials are advocated as essential educational resources (as discussed extensively in Chapter 6), their implementation in practice often collides with teachers' pragmatic capacities and design expertise. For instance, although the literature broadly recognises the crucial role tactile materials play in VIC education (Sheppard & Aldrich, 2001; Rosenblum et al., 2018), teachers frequently experience tension when asked to implement sophisticated TG without adequate training or sufficient resources. This contradiction is further intensified when teachers, faced with limited institutional support and constrained schedules, default to simplified materials or traditional pedagogical methods that fail to fully leverage the potential of TG. Consequently, despite recognising their educational value, the practical limitations frequently result in the underutilisation or superficial use of these pedagogical tools, undermining the very intention of co-design initiatives.

Another substantial secondary contradiction observed in this study emerged between the rules component—comprising institutional assessment policies, teaching standards, and curriculum guidelines—and the object of the activity system, namely, designing inclusive, learner-centred activities. Educational institutions in China, characterised by strongly embedded traditions of examination-focused and result-oriented approaches (Evans, 1996), present structural barriers to adopting the more flexible, participatory ethos inherent in co-design. These tensions became evident throughout the fieldwork, particularly when VIC's individualised needs contradicted standardised evaluation methods used by institutions. Here, educators grappled with institutional expectations of uniformity and measurable outcomes (Brown & Beamish, 2012;

Engel & Weber, 2017), clashing with the personalised learning aims central to effective co-design. As Chapter 5 extensively details, teachers reported ongoing difficulties in reconciling institutional expectations for conformity with their pedagogical commitment to adaptive, responsive, and differentiated learning experiences. These contradictions necessitated continuous negotiation, often leading teachers and designers to creatively navigate—and at times strategically circumvent—institutional barriers.

Additionally, another crucial secondary contradiction arose between objects and the community component (comprising guardians, institution administrators, and society). Although existing literature (e.g., Florian & Black-Hawkins, 2011; Brown & Beamish, 2012) underscores the importance of collaborative engagement in educational innovation, this study's findings highlight significant practical challenges in achieving authentic co-design. Institutional hierarchies and entrenched professional roles often constrained communication, limiting meaningful collaboration between teachers, VIC, and designer. Guardians, in particular, whose expectations and conceptualisations of effective teaching and successful learning outcomes often differ markedly from those promoted within co-design approaches. They are accustomed to conventional education paradigms emphasising immediate and quantifiable outcomes, often initially resisted participatory, open-ended approaches (Huang et al., 2019; Treagust et al., 2023). Teachers and designer alike reported challenges in effectively communicating the pedagogical value and benefits of participatory co-design methods to parents accustomed to traditional performance-based assessments. Thus, these secondary contradictions between external expectations and co-design objectives highlight the critical role of communication strategies in negotiating change, reinforcing recent scholarship that stresses the importance of clarity, alignment, and shared values in co-design contexts (Steen, 2013; Sanders & Stappers, 2008).

9.3.3 Tertiary Contradictions

This study demonstrates that tertiary contradictions often emerge when participants—teachers, the designer, and VIC—are introduced to new objectives or paradigms that disrupt previously stable configurations. Such contradictions were evident when introducing the co-design process into an educational context historically shaped by authoritative teaching approaches and strict adherence to curricular frameworks. In Chapter 5, 7 and 8, the findings explicitly highlighted these transitional tensions. For example, when teachers were introduced to co-design methods emphasising children's active participation, voice, and creativity, many expressed apprehension, perceiving potential disruptions to classroom control, curriculum adherence, and traditional assessment metrics. This aligns with findings by Florian and Black-Hawkins (2011) and Gale et al. (2017), who argue that adopting inclusive pedagogical approaches inevitably challenges entrenched institutional norms and educators' existing pedagogical strategies. The tertiary contradictions identified here were thus characterised by resistance not born of reluctance, but rather from professional uncertainty regarding how best to reconcile innovative co-design methodologies with historically entrenched pedagogical paradigms. These tertiary contradictions can be conceptualised as "epistemological tensions", indicating fundamental differences in beliefs about the nature of knowledge creation, learner roles, and educational objectives (Sørensen, 2009; Sanders & Stappers, 2008). Thus, the introduction of co-design practices disrupted not just pedagogical routines, but also underlying epistemological assumptions, forcing teachers to question deeply-held beliefs regarding authority, control, and knowledge transmission.

Nevertheless, the analysis presented in this study suggests that tertiary contradictions, despite causing initial resistance and uncertainty, hold substantial transformative potential. When teachers and designer explicitly recognised and actively negotiated these contradictions, significant professional learning occurred, leading to innovative adaptations and expanded pedagogical practices. In Chapter 7 and the workshops detailed in Chapter 8, it was observed how teachers gradually transitioned from initial doubt towards increased engagement and enthusiasm for co-design processes, as they experienced first-hand the beneficial outcomes of increased learner agency and creativity. This progression exemplifies Engeström's concept of expansive learning, where contradiction-driven tensions become the driving force behind new forms of activity, practice, and professional understanding (Engeström, 2001, 2016).

Tertiary contradictions also profoundly influenced the ways material artifacts were perceived and utilised. Historically, tactile materials were frequently employed as static educational tools—predesigned by external experts and presented to PVI in a didactic manner (Mukhiddinov & Kim, 2021). However, introducing co-design radically reconfigured these practices, as students themselves became active co-creators of tactile materials. This paradigmatic shift—from passive use to active participation—represented a significant tertiary contradiction, reshaping how materials were designed, perceived, and valued within pedagogical contexts. In line with Ingold's (2012) assertion that materials are active participants shaping socio-material interactions, this study further revealed how tactile materials, when repositioned as co-created protagonist, transformed from passive tools into dynamic sites of engagement, collaboration, and meaning-making.

Moreover, tertiary contradictions were vividly manifested through evolving perceptions of professional roles. Designers, historically positioned as authoritative experts delivering fixed solutions, transitioned towards roles of facilitators, negotiators, and collaborators. Teachers similarly evolved from authoritative transmitters of predefined curricula toward more flexible, adaptive designers engaging collaboratively with VIC. These role transitions represent substantial professional shifts requiring active negotiation of tertiary contradictions, highlighting the significant challenges inherent in implementing inclusive co-design within historically hierarchical and authority-driven educational cultures (Brown & Beamish, 2012; Gale et al., 2017; Sangiorgi et al., 2022). As discussed extensively in Chapter 7, sustained reflection and dialogue facilitated the gradual resolution of these tensions, encouraging professional identity shifts necessary for adopting co-design practices effectively.

Crucially, tertiary contradictions in this research illuminated the historical embeddedness of educational practices and underscored the necessity of attending to these historical dimensions when implementing pedagogical innovations. Engeström (2001) emphasises that any new object or practice inevitably engages with historically rooted activity systems, suggesting that successful innovations must acknowledge, negotiate, and transform historical legacies. This study's findings align closely with this theoretical insight, demonstrating how explicitly engaging teachers and VIC in dialogue regarding historical pedagogical practices and expectations facilitated smoother transitions towards new co-design methods. Ultimately, tertiary contradictions in this study revealed the inherent complexities, tensions, and transformative possibilities involved in shifting historically embedded educational paradigms toward more inclusive, collaborative, and VIC-centred co-design approaches. While these contradictions initially posed significant challenges, they also provided critical opportunities for reflective practice, professional learning, and institutional change.

9.3.4 Quaternary Contradictions

Quaternary contradictions surface prominently when activity systems interact, collaborate, or intersect, particularly within interdisciplinary or inter-institutional projects. Within the context of this study—co-designing inclusive pedagogical activities for VIC—quaternary contradictions emerged vividly at intersections between teachers' institutional practices, designers' professional methods, and external stakeholders' (e.g., experts, families, and societies) expectations. These contradictions provide crucial insights into the complexity and multi-dimensionality of co-design and suggest pathways for productive interdisciplinary and inter-systemic collaboration.

A significant quaternary contradiction uncovered through this research involves the tensions arising between the core educational activity system (e.g. routine activities in section 5.2.3) and external activity systems such as professional design teams, specialist organisations, and educational policymakers (e.g. extraneous activities in section 5.2.3). Teachers and outsiders participating in co-design activities frequently articulated tensions regarding differing priorities, expectations, and professional logics, particularly visible during collaborative workshops. For example, guardians, grounded in institutional mandates emphasising measurable educational outcomes, frequently perceived co-design methods advocated by designers as less directly aligned with conventional educational standards. This tension highlights significant cultural dimensions, echoing the findings of researchers (Hornby & Lafaele, 2011; Osorio-Saez et al., 2021), who identify parental attitudes and expectations as critical elements influencing the acceptance and sustainability of inclusive educational innovations. Conversely, designer, guided by inclusive design methodologies and participatory principles (Sanders & Stappers, 2008; Steen, 2013), found institutional frameworks overly restrictive, constraining their creative, exploratory, and reflexive design practices. As Engeström's (2001, 2015) notion that contradictions often surface at boundaries where distinct professional communities intersect. Such contradictions are not merely disagreements on methodologies, but rather reflect deeper epistemological tensions concerning what constitutes valid knowledge, effective learning, and valuable educational experiences. Similar tensions are highlighted by Florian and Black-Hawkins (2011) and Gale et al. (2017), who argue that inter-systemic collaborations frequently challenge entrenched educational conventions, requiring sustained negotiation and alignment among stakeholders.

The inter-systemic nature of quaternary contradictions also became apparent through the professional training and preparation of teachers. Institutional teacher-training programmes typically prioritise conventional pedagogical methods, resulting in teachers frequently feeling ill-equipped to engage with the more complex, interdisciplinary, and collaborative skills inherent in co-design. This mismatch represents a systemic contradiction between the pedagogical training institutions provide and the professional skills actually demanded by participatory and inclusive design processes (Maher et al., 2020; Florian & Black-Hawkins, 2011). This research confirms the critical need for educational institutions and policymakers to rethink professional development curricula, incorporating explicit training and resources supporting interdisciplinary collaboration, reflective practice, and design-based pedagogical approaches.

Importantly, the study demonstrates that quaternary contradictions, although initially disruptive, possess transformative potential when effectively recognised, managed, and negotiated. Teachers and designers often experienced these contradictions as opportunities for expansive professional learning, driving collaborative dialogues and reflective practice. Such negotiations fostered mutual understanding, encouraging educators and designers to appreciate distinct disciplinary perspectives, methods, and epistemologies. Moreover, successful management of contradictions underscores the importance of boundary-crossing competencies, such as communication, negotiation, and translation skills (Hisherik et al., 2025; Lehtinen et al., 2025). Teachers and designer who successfully navigated these contradictions actively developed sophisticated competencies to translate ideas, values, and methods across professional and institutional boundaries. This boundary-crossing capacity, observed consistently throughout the co-design process detailed in this study, emerged as an essential attribute of successful interdisciplinary collaboration and sustainable educational innovation.

9.4 Expanding the Subject: Transitioning to Intentional and Skilled Co-design for the Future

The socially situated and, for teachers, novel practice of co-design expanded their professional repertoire. Specifically, the development of a design mindset and related skills, as evidenced through prototyping and workshops, reflects and extends earlier findings (e.g., Örnekoğlu-Selçuk et al., 2024; Voogt et al., 2016). However, this research elucidates more nuanced qualities that empirically define and refine teachers' design growth trajectories (Figure 7.9). Overall, the guided, holistic, and collective approach to designing for VIC disrupted teachers' historical reliance on individualistic, tacit, and less systematic design methods. As Engeström (2001, p. 137) contends, "An expansive transformation is accomplished when the object and motive of the activity are reconceptualized to embrace a radically wider horizon of possibilities than in the previous mode of the activity." This study's evidence suggests that teachers reimagined "design", particularly in a VIC learning context, by broadening its scope, sharpening its focus, and growing more adept at adopting design-based practices, supported by relevant mediating knowledge and resources. Central to these transformations was the development of what McKenney et al. (2015) frame as an interplay among the 'know what,' 'know how,' and 'know why' aspects of design expertise. Teachers began to exhibit adaptive expertise (Stevenson et al., 1986), deliberately reproducing and adjusting design practices developed in one context for new educational scenarios. This adaptability is crucial, particularly amid rapidly evolving educational climates, enabling educators to navigate emerging challenges with agility and reflexivity (Goodyear et al., 2021).

A crucial insight from this study, extending the existing literature, was that the collaborative dimension of co-design significantly enhanced teachers' metacognitive awareness and reflective practice. As participants worked collaboratively with the professional designer—particularly in the structured, guided workshops detailed in Chapter 8—they became consciously aware of their cognitive processes, engaged in systematic self-monitoring, and practiced deliberate reflection-in-action (Kiernan et al., 2020). The scaffolded nature of interactions facilitated by designer was instrumental in moving teachers through their zone of proximal development (Vygotsky, 1978). This developmental progression contributed directly to forming rich, context-specific design schemata, enabling teachers to more effectively respond to complex pedagogical challenges independently in subsequent design engagements.

The research also illuminated the critical role of interdisciplinary collaboration in facilitating sustainable growth in teachers' design competencies. As Dorst (2019, p.121) argues, "Design is often a team effort, so there can be more than one actor working in unison." The chapter 8 indicates that more robust collaborative relationships—characterised by sustained interactions among teachers and the designer—led to deeper professional transformations and institutional shifts towards collaborative cultures. Notably, workshops involving multiple stakeholders (e.g., teachers, designer, and institutional support staff) demonstrated greater fluency and effectiveness in decision-making than scenarios where collaboration was constrained. These findings align with Hakkarainen et al.'s (2013) assertion that collaborative inquiry represents not merely a methodological approach but a developmental process that nurtures a collective memory, fostering institutional cultures of shared wisdom and effective practice repertoires.

Moreover, this study introduces the novel finding of teachers' evolving professional identities as leaders in inclusive educational design, particularly in tactile learning contexts. Teachers who actively participated in co-design workshops reported increased confidence in articulating pedagogical visions, demonstrating leadership through evidence-informed advocacy, and systematically addressing barriers encountered during the design process. Rather than asserting leadership from traditional hierarchical positions, participants cultivated a form of leadership rooted in experiential credibility, reflective understanding, and a well-rounded comprehension of institutional ecosystems (including resources, processes, and personnel interactions). Such professional transformations potentially have far-reaching implications for institutional development, providing valuable insights into enhancing systemic capacities for inclusive education, as argued by Goodyear (2022) and Aitchison et al. (2020).

Significantly, the findings also underscore the value of co-design processes in promoting educational sustainability. Although tangible outcomes such as the direct reuse of designed tactile and multimodal resources were evident, the broader sustainability impact highlighted the lasting shifts in teachers and designer's design habits, reflective practices, and collaborative norms. Participants demonstrated a sustained willingness and capability to reuse, adapt, and extend co-designed learning artifacts across varying educational contexts, signifying enduring value beyond initial implementations. This supports Dorst's (2019) assertion that effective design outcomes inherently possess transformative teleologies, continually evolving to meet new demands and circumstances.

Collectively, these insights point towards a significant paradigm shift from historically isolated and tacit design practices towards intentional, collaborative, and adaptive co-design activities that intentionally expand the professional agency of both teachers and designer. The study advocates for institutions to proactively nurture this transition by providing ongoing professional development opportunities, resources, and organisational structures that facilitate interdisciplinary collaboration, reflective practice, and adaptive expertise.

9.5 Extending the Object: Fostering Growth and Expansive Learning for VIC

In the context of VIC education, extending the object means that learning goals are no longer confined to narrow learning targets; instead, they evolve into broader, more creative, and collaborative pursuits shared by teachers, designer, and VIC. In this research, the initial object—for example, teaching a specific concept or creating a tactile graphic—became expanded into a shared, co-created objective: to design inclusive learning experiences that empower VIC as active participants. This expanded object is not a fixed target but a dynamic, "partially common" goal emerging between interacting activity systems (e.g. a teachers' instructional system and a designer's development system). By bringing multiple perspectives to bear on a problem, the co-design process transformed the object of learning from a static lesson into a living, evolving project that all participants owned and continually reshaped. In the study, this meant that the aim of a lesson or design task was progressively reframed—moving from an initial, unreflected idea of providing information to a collectively meaningful goal co-defined by teachers, designer, and children, and eventually toward a jointly expanded object embodying new inclusive practices. This discussion examines how extending the object in this way enabled expansive learning for VIC, manifesting in heightened children agency, engagement, material interaction, and embodied cognition.

Central to this expanded object was redefining VIC's roles from passive recipients of instruction towards active, creative, and capable co-designers of their learning environments. This shift aligns with a growing body of scholarship advocating learner agency and active participation as foundational principles for inclusive education (Magnusson et al., 2017; Mojtar-Mendieta et al., 2025; Vallee, 2017). Findings detailed in Chapter 8 indicate that, when VIC contributed significantly to design decisions—particularly through the collaborative creation of *dragon* designs—they exhibited heightened motivation, deeper conceptual engagement, and increased confidence in expressing their unique perspectives. As Wenger (1999) contends, learning is intrinsically linked to identity formation; when learners participate meaningfully in their learning communities, they develop identities as capable contributors rather than passive recipients. Echoing this, findings from this research indicate that when VIC took active roles in co-designing TG and learning artifacts, they began to articulate their insights confidently and demonstrate increased self-efficacy, profoundly altering perceptions of their own competencies. Such outcomes support existing calls within inclusive pedagogy and disability studies literature to shift educational narratives toward recognising and leveraging children's strengths, autonomy, and creativity (Cappiali, 2023; Liu & Xu, 2011; Naraian & Schlessinger, 2018).

This research further demonstrates that extending educational objects toward material interaction and embodied cognition significantly enhanced learning experiences for VIC. Rather than viewing tactile materials merely as compensatory tools, the co-design process repositioned these materials as central, active mediators of learning. Drawing upon Ingold's (2013) concept of correspondence, where knowledge emerges through interaction between individuals and materials, the study's expanding findings showed that VIC's tactile explorations generated deeper cognitive and conceptual understandings. For instance, the clay-modeling for numeracy concepts transformed abstract mathematical knowledge into embodied, tactile experiences. VIC's comments indicated that these material engagements allowed them to perceive mathematical shapes and relationships in ways inaccessible through conventional didactic methods alone. These findings underscore literature emphasising multisensory and embodied learning as foundational for meaningful cognition among CwD (Fugate et al., 2019; Kucirkova & Rodriguez-Leon, 2023; Pagliano, 2012). Through active material manipulation, VIC built embodied schemas, or tactile/auditory memories, linking abstract concepts to concrete experiences. Also, the expansive learning fostered through embodied materiality positions VIC as active constructors rather than passive learners of knowledge, echoing contemporary calls within education for learning experiences that leverage learners' sensory strengths and experiential knowledge (Kolb & Kolb, 2005; Schmidt et al., 2024).

Expanding the object of learning was also significantly facilitated by collaborative boundary-crossing among teachers, designer, and VIC. This aligns with Engeström's notion that expansive learning occurs precisely at the intersection of different professional and disciplinary boundaries, where new practices can emerge from diverse viewpoints (Engeström, 2001, 2015). Indeed, the present research shows how collaborative co-design transformed pedagogical relationships. For instance, teachers shifted from instructional roles to collaborative co-design facilitators, designer moved from external experts to embedded educational partners, and children transitioned from passive learners to active co-designers. These boundary-crossing interactions enabled the creation of new "third space" (Akkerman & Bakker, 2011; Whitchurch, 2008)—places where traditional role divisions were renegotiated, and participants could jointly define shared educational goals. Although institutional rhetoric frequently espouses child-centred learning, actual structures and practices often reinforce a community-centric lens. In comparing the shift from a community-focused view to one centred on the child, it appears that child-centred learning functions as the critical boundary concept, while collaboration offers one of several pathways once this conceptual threshold is crossed (Bullinger et al., 2010; Cook-Sather, 2014; Castañer & Oliveira, 2020). Such collaboration fosters conditions where each stakeholder redefines their identity and expands their professional boundaries, thus illuminating pathways for inclusive educational design.

Finally, extending the object of educational activity to foster expansive learning has notable institutional and cultural implications. By redefining educational objectives to include learner agency, embodied cognition, and collaborative practice, this research has demonstrated a sustainable pathway toward systemic educational innovation. At an institutional level, teachers' professional identities expanded significantly, incorporating designerly thinking, reflective practice, and an increased willingness to experiment with inclusive pedagogy—resonating with McKenney et al.'s (2015) ecological framework for sustained professional development. Additionally, at a cultural level, the expanded educational object challenged prevailing deficit-based narratives around disability and special education, promoting a more inclusive and participatory ethos. The institution involved in this study began to recognise the broader value of co-design beyond mere accessibility adjustments. Communities saw first-hand that co-design activities could foster broad-based learner engagement, creativity, and collaboration, thereby shifting institutional narratives toward valuing diversity as an educational asset. Such cultural shifts are essential, as they create conditions under which inclusive design innovations become embedded within institutional practices rather than isolated projects (George et al., 2012; Lashitew et al., 2020).

9.6 Further Reflections

Co-design positions itself explicitly as a democratic and inclusive methodology, promising to elevate the voices and agency of marginalised groups within design processes (Drain et al., 2018; Jagtap, 2022; Raman & French, 2022). Yet, despite this conceptual clarity and ethical aspiration, translating these democratic ideals into practice, especially with VIC, has revealed intricate challenges and complexities that are seldom fully acknowledged in literature. Reflecting critically upon my experiences throughout this research, there are three complexities encountered repeatedly:

- One primary complexity encountered repeatedly was the subtle yet pervasive influence of traditional hierarchical dynamics within Chinese educational contexts. Although the explicit aim of the co-design activities was to empower VIC as equal designers, the deeply entrenched educational culture, characterised by clearly delineated adult-child roles, persisted beneath the surface of interactions. It was frequently observed that children’s contributions and suggestions during design workshops tended, whether consciously or subconsciously, to align with what they perceived as expectations of adults. This means that institutional power dynamics often unintentionally reproduce patterns of compliance and conformity rather than encouraging genuine learner autonomy (Boud, 1988; Collyer, 2015; Henkel, 2005). While the methodological ideal was one of open and democratic co-creation, the reality of children's socialisation within authoritarian educational environments subtly constrained their freedom to openly dissent, critique, or express innovative ideas that might differ markedly from adult expectations.

- Methodological reflections on the interviews illuminated how participation itself can become compromised by subtle forms of performativity. Despite careful attention to inclusive facilitation practices and structured engagements designed to encourage authentic expression, VIC sometimes appeared inclined to provide answers or contributions that catered to the perceived desires of teachers and researcher. The complexity here is amplified by the unique cognitive and communicative dynamics associated with visual impairment, where children might rely more heavily on established relationships and trusted adult figures, thus further accentuating the influence of teacher and researcher preferences.
- Another significant challenge identified was the frequent occurrence of unforeseen practical obstacles specific to working with VIC, including communication barriers, fatigue, concentration difficulties, and challenges in articulating abstract design ideas in tactile terms. Initially underestimated, these issues significantly affected the participatory quality of study. Although adaptability, flexibility, and increased methodological sensitivity developed over time provided partial mitigation, these challenges remained persistent, emphasising the need for continual adaptation. Indeed, the experience underscores the methodological necessity of approaching co-design as an evolving, dynamic practice rather than a rigid set of protocols. It highlights the importance of iterative learning, wherein practitioners and researchers refine approaches continually, guided by participants' evolving capacities, interests, and feedback.

Reflecting honestly upon these complexities has brought into sharp relief the tension between the aspirational goal of 'democratisation'—the fundamental ethos underpinning co-design—and the realities encountered during its implementation. This research indicates that full democratisation remains aspirational, particularly when working within deeply entrenched hierarchical educational structures. Nevertheless, acknowledging this gap does not invalidate the approach; rather, it underlines the critical necessity of pursuing incremental and iterative methodological improvements. Co-design, therefore, should not be evaluated purely on whether full democratisation is immediately achieved, but rather on whether the process continuously and authentically strives toward more equitable and meaningful participation over time.

Further reflection also underscores the critical role of trust and relationality as foundational elements of effective co-design practices. The findings from this study reveal that authentic participation and meaningful dialogue emerged when trust was systematically cultivated among designer, teachers, VIC, and their broader community. This trust extended beyond mere rapport; it represented a shared belief in the legitimacy and value of each participant's experiential and professional knowledge. As highlighted by Kliskey et al. (2023), trust and relationality within design are often overlooked yet profoundly impact both process and outcomes. Within this study, teachers initially exhibited hesitance in allowing children-driven design, however, as trust grew through sustained collaboration and iterative interactions with designer, teachers began embracing co-design methodologies as beneficial rather than burdensome. Similarly, VIC's confidence in articulating their perspectives increased markedly as trust deepened, indicating that co-design practices are as much relational processes as they are creative endeavours. This insight invites further scholarly exploration into the affective dimensions of co-design, challenging designers and teachers to cultivate relational skills explicitly and intentionally within their practices.

More importantly, this thesis advances design for learning in two interconnected ways. First, it consolidates co-design as pedagogy rather than merely a method. Across

Chapters 5-8, co-design practices did not simply yield better artefacts; they reorganised classroom relations and routines such that learning was enacted through joint interpretation and material doing. In a design-for-learning perspective, this maps onto the long-argued distinction between what can be designed in advance (tasks, tools, social configurations) and what must be orchestrated responsively in situ (contingent actions, emergent intentions, and shared negotiation) (Dillenbourg, 2013; Goodyear & Carvalho, 2014). The study shows that when teachers, children, and designers iteratively frame and re-frame problems with materials at hand, the unit of analysis of learning shifts from individual cognition to collective activity, thereby validating co-design as a pedagogical arrangement that cultivates agency and sense making for VIC. In this light, the six features identified in the empirical chapters—especially role shifts, sociomateriality, generativity, and fluid hierarchies—function as pedagogical mechanisms that make inclusive learning possible under real institutional constraints.

Second, the thesis specifies the sociomaterial role of materials in orchestrating learning. Rather than treating clay, nets, tactile books, or the built environment as neutral carriers of content, the analysis foregrounds how their sensory and structural affordances configure attention, participation, and sequencing of joint action—what Sørensen terms the materiality of learning (Sørensen, 2009). This extends design-for-learning by positioning materials as co-participants in classroom orchestration: they shape who can do what, with whom, and when, while teachers improvise around these constraints and possibilities. In doing so, the findings translate sociomaterial theory into practical implications for lesson design: material selection and arrangement become levers for redistributing participation, scaffolding exploratory touch, and staging progressive abstraction, aligning with accounts of sociomaterial practice in education and work (Orlikowski, 2007; Dillenbourg, 2013; Goodyear & Carvalho, 2014). This contribution synthesises the argument that effective learning designs depend not only on planned goals but also on materially mediated repertoires that support situated orchestration.

Finally, a crucial reflection emerging from this research pertains to the broader institutional implications of adopting inclusive co-design methodologies. Institutional sustainability in inclusive pedagogy innovation demands more than isolated interventions; it requires fundamental cultural shifts toward recognising diversity as inherently enriching educational environments (Gay, 2013; Irvine, 2003). The sustained professional growth among teachers, the empowerment and agency observed among VIC, and the receptivity of community to embrace co-design as standard practice suggest promising pathways for long-term transformative change. Nevertheless, as evidenced by this study, creating environments conducive to co-design innovation entails intentionally fostering cultures of reflection, experimentation, and collaboration at multiple levels of institutional practice. Ultimately, embracing these reflections positions co-design not merely as an educational strategy but as a fundamental practice in cultivating equitable, participatory, and transformative learning communities.

10. Conclusion

*I conclude this study entitled **Co-Design as Pedagogy** to outline the key insights and highlighting the study's contributions to knowledge. It also discusses the practical implications, limitations, and broader significance of the research, and explores future directions for development and application across stakeholders and within wider educational practice.*

10.1 Findings

Initially, I emphasised that the central focus of this research lies in the importance of knowledge-sharing and the development of mutual understanding (Steen, 2013). I proposed that co-design could be conceptualised and structured either as a collaborative design thinking process, or, drawing upon Fischer et al. (2021), as a process of learning. In this study, I endeavoured to build a bridge connecting design practice, pedagogy, and the learning experiences of VIC, thereby enabling a broader understanding of how co-design can function as a transformative pedagogical tool. Through the production of this thesis, I have come to perceive co-design from different perspectives, documenting my findings in ways that may assist others in reflecting upon the significance of their roles. Inspired by interdisciplinary scholarship, I have drawn insights from sociology, anthropology, archaeology, education, and philosophy to interpret my observations. However, my intent was not merely to highlight the interdisciplinary nature of co-design, nor simply to argue that we must broaden our definitions of knowledge, materials, design, and learning. More importantly, I sought to demonstrate specifically how co-design can serve as a transformational educational practice, reshaping the roles, relationships, and modes of action among participants, thus contributing to a more inclusive and empowering educational future.

This chapter returns to the four research questions that framed this investigation and summarises key findings. These findings have been brought together into a visual representation (Figure 10.1) to facilitate a more rounded view.

> RQ1. *How do teachers conceptualise and implement design strategies in developing learning materials and activities for visually impaired children*?

The findings underscore the view of teachers as designers who actively craft multisensory learning experiences tailored to the diverse cognitive and sensory needs of VIC. Teachers' design practices are articulated through multiple pedagogical modes: adaptive, contingent, routine-based, unavoidable, and infrastructural. Adaptive design strategies involve pre-structured yet responsive activities that integrate tactile, auditory, and proprioceptive cues, enhancing spatial awareness and motor coordination. Contingent strategies reflect teachers' real-time responsiveness to children's immediate feedback, emphasising tactile exploration and differentiated fine motor skill development. Routine-based design embeds spatial and temporal continuity within daily practices, supporting autonomy and independence. Unavoidable activities—such as spontaneous external engagements—demonstrate how teachers mediate incidental yet influential learning opportunities, enriching VIC's sensory and social experiences. Infrastructural designs facilitate fundamental routines through tangible object-based scheduling and tactile symbolic representations, fostering environmental accessibility.

The results identified five key thematic factors influencing teachers' decision-making processes: variability, ambiguity, uncertainty, restrictiveness, and adaptation. Variability arises from individualised assessments and observations of VIC, requiring constant recalibration of instructional strategies. Ambiguity emerges from inherent pedagogical uncertainties, notably memory retention and non-verbal communication, compelling teachers toward iterative and speculative approaches. Uncertainty is amplified through collaborative dynamics involving parents, specialists, and institutional constraints, necessitating ongoing negotiation and interdisciplinary dialogue. Restrictiveness addresses systemic barriers, including resource limitations, societal biases, and economic disparities, which fundamentally shape the educational environment. Adaptation characterizes teachers' continuous refinement of multisensory teaching methods and learning materials, emphasizing iterative design processes responsive to children's evolving needs.

The study further delineates critical design implications, emphasising individualised, needs-based design processes; expanding multisensory strategies; balancing standardisation with customisation; iteratively refining learning materials; and strengthening collaborative networks. These implications advocate for pedagogical materials that are modular, flexible, scalable, and responsive, embedded within collaborative professional communities. Overall, the interplay of these dimensions underscores the necessity of viewing design as a dynamic, recursive process—a continuous negotiation between pedagogical ideals and the lived realities of VIC.

> RQ2. *How do materials shape learning activities for visually impaired children, and how do their properties influence interaction, meaning-making, and learning outcomes*?

The chapter 6's findings highlight the active and transformative role of materials within educational settings for VIC, revealing materials not merely as passive instruments of pedagogy, but as protagonists shaping the sensory, cognitive, emotional, and social dimensions of learning experiences. The analysis demonstrates that the properties of materials—such as tactility, texture, weight, flexibility, and sensory responsiveness—significantly mediate and enhance the interactions between children and their learning environments. Materials thus act as pivotal agents that facilitate embodied meaning-making, cognitive engagement, and relational dynamics within pedagogical contexts.

Specifically, four illustrative materials were examined closely: nylon netting, ultralight clay, tactile books, and the Perkins Brailler, each exemplifying distinctive pedagogical affordances. The nylon net, initially installed as a safety feature, evolved into an instrument of tactile-spatial pedagogy, teaching VIC to navigate space through embodied interactions, while its properties such as lightweight flexibility and texture fostered tactile sensitivity, confidence, and spatial literacy. Ultralight clay emerged as a dynamic medium for embodied cognition, allowing children to physically manipulate abstract concepts (e.g., Arabic numerals), thereby translating conceptual learning into somatic experiences through its pliable, responsive, and forgiving nature. Tactile books, characterised by diverse textures and handmade authenticity, facilitated intimate multisensory literacy experiences, turning reading into a process of sensory dialogue and narrative co-construction. The Perkins Brailler's robust, mechanical simplicity provided both consistency and reliability, underpinning structured tactile literacy, though also exposing tensions between institutional demands for precision and individual children's experiences of sensory engagement.

Further, the relationship between VIC and materials extended beyond the purely cognitive to encompass emotional and social dimensions. Children's distinct tactile preferences, emotional resonances, and relational engagements with materials—such as preferences for familiar objects or aversions to certain textures—revealed that sensory interactions significantly shape learning outcomes, emotional states, and social interactions. This emotional-material nexus was evident in how everyday materials mediated social interactions, creating both communal harmony and occasional friction, thereby fostering opportunities for social negotiation, conflict resolution, and collective identity formation.

Teachers played a crucial role in this process, strategically selecting, curating, and adapting materials to individual children's sensory profiles and developmental needs. This mediation underscored the necessity for teachers to possess a nuanced understanding of how material properties translate into pedagogical qualities, thus shaping the conditions for meaningful and inclusive engagement. Teachers' interventions demonstrated an essential responsiveness to the sensory, cognitive, and emotional demands of each child, embedding material encounters within personalised learning trajectories. By actively shaping interactions, meaning-making, and learning outcomes, materials embody a critical component of inclusive design for VIC.

> RQ3. *How do designers negotiate the roles, relationships, and power dynamics between materials, teachers, and visually impaired children during the co-design*?

Chapter 7 positions the designer as a critical mediator who actively negotiates roles, relationships, and power dynamics among materials, teachers, and VIC within co-design practices. Analysis of interview and prototyping data through the lens of CHAT identifies that co-design is inherently a negotiated practice characterised by continuous recalibration of authority, collaborative refinement, and dynamic responsiveness to the sensory and cognitive needs of VIC. The designer facilitates an iterative negotiation process that is essential for equitable collaboration, and the creation of inclusive learning environments, wherein negotiation becomes central rather than peripheral to the design process.

The findings reveal six interconnected thematic domains in this negotiation: reframing roles and expertise, managing power dynamics, mediating through materials, fostering collaboration and communication, ensuring accessibility and inclusion, and navigating contextual influences. Roles and expertise within co-design processes were found to be fluid rather than fixed, with designer actively mediating among diverse areas of knowledge. The designer acts as translator, reconciling teachers' pedagogical expertise with the technical and aesthetic demands of material production. Notably, the traditional hierarchy between designer and teacher was redefined into a collaborative, co-regulatory model, where teachers' classroom insights significantly shaped designer's approaches, and designer's professional knowledge provided essential input. Children's active participation was also foundational; their learning experiences and direct feedback were integral to validating and refining design choices, ultimately influencing final outcomes and enriching the participatory nature of the design process.

> RQ4. *What are the key features of the co-design process involving visually impaired children*?

The analysis presented in chapter 8 demonstrates that the co-design process involving VIC extends beyond the mere collaborative production of educational materials; rather, it constitutes a rich, dynamic, and context-sensitive activity system, which fundamentally reshapes relationships, roles, and pedagogical practices. Grounded in observations from carefully structured workshops, six defining characteristics emerged that underline the transformative nature of co-design involving VIC: role shifts, sociomateriality, generativity, divergence, self-reliance, and fluid hierarchies.

The findings revealed significant shifts from traditional, fixed adult-child power dynamics toward fluid, reciprocal interactions. Initially clearly defined roles—teacher as orchestrator, designer as facilitator, and children as learners—became progressively permeable, allowing children to assert increasing levels of agency and control over their creative decisions. Adults correspondingly transitioned into supportive, responsive roles, positioning children’s immediate sensory, emotional, and cognitive needs at the forefront of the creative process. The reciprocity fostered by these shifting roles enhanced the children's confidence and ability to articulate their design intentions clearly, redefining the boundaries of expertise within the co-design space.

A key finding was the emphasis on sociomaterial interactions, highlighting the interplay between children’s tactile and sensory exploration of materials and the social dimensions of their engagements. Materials functioned not as passive resources but as active collaborators shaping children's imaginative processes. Children’s spontaneous tactile interactions guided creative trajectories, whereby material properties directly influenced decision-making, and social interactions—such as sharing insights or materials—shaped collective outcomes. Thus, sociomateriality manifested as an interconnected dialogue, integrating human action and material affordances into a unified and co-constitutive design experience.

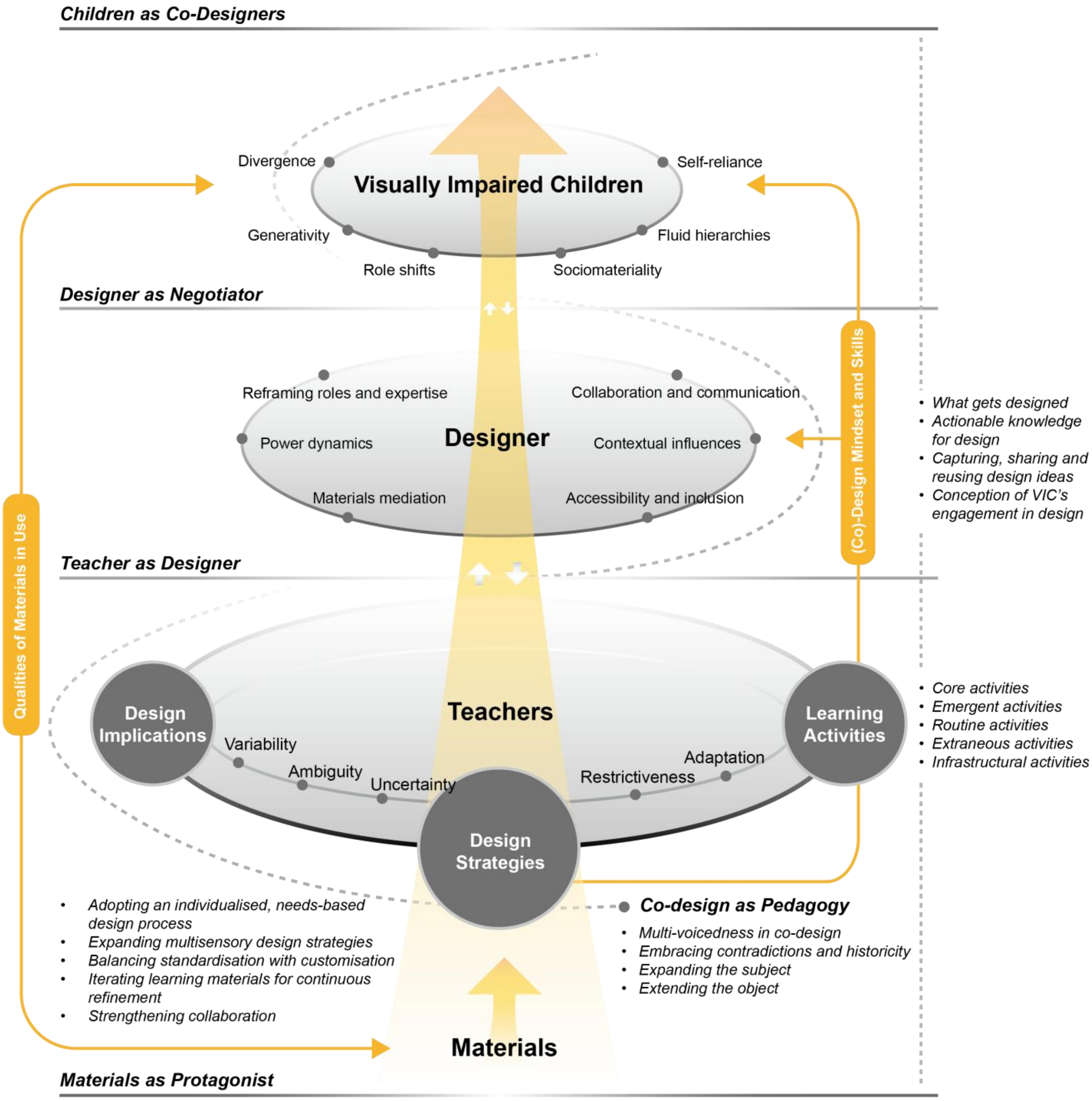

Figure 10.1. Visual representation of key findings in this study.

Collectively, Figure 10.1 illustrates the key findings outlined above. These findings emphasise co-design as an inherently relational practice, critically dependent on sensory engagement, experiential knowledge, and continuous negotiation among all participants. The identified key features illustrate how co-design can alter pedagogical expectations and social interactions, ultimately fostering inclusive, empowering, and responsive educational experiences for VIC.

10.2 Contributions

This study delivers a rich, evidence based portrait of educational co-design by interweaving teachers' and designer's perspectives within a single investigation. It positions co-design with VIC as an intrinsically relational, context bound endeavour—a view elaborated throughout the previous chapters. By foregrounding the day to day practices of both professional groups, the thesis extends existing debates on co-design with practice oriented insights that illuminate how teachers and designers actually navigate the design process. Positioning co-design as hermeneutics in praxis clarifies the thesis's theoretical contribution: it specifies how learning arises from cycles that couple interpretation with material action, under conditions of negotiated constraints. This lens helps explain the expansion of teacher practice and children's agency observed in the cases and indicates where co-design, as pedagogy, exceeds instrumental "problem-solving" to become a pluralistic enactment of realities.

My contribution interweaves new insights from close interview, observation and theoretical reflection, and demonstrates some of the potential implications of interdisciplinary collaborative design as follows:

- It innovatively integrates CHAT into inclusive education contexts for VIC, offering a comprehensive analytic framework that captures the complexity of interactions (Chapter 3).
- It provides a critical methodological tool for understanding the intricate dynamics that shape design for learning experiences, interactions, and outcomes, significantly contributing to qualitative research practices in

design based studies (Chapter 4).

- It reveals that design for VIC is not a static endeavour but a recursive, improvisational process, shaped by the interplay of adaptive intentionality, contingent responsiveness, and systemic negotiation (Chapter 5).
- It shows how case study of specific materials can be used to trace relations between form and learning activity (Chapter 6).
- It illustrates the value of exploring the properties of materials, and tracing their associated qualities in use (Chapter 6).
- It presents some of the key findings from the design-test-iterate scenario that others may use and repurpose in other similar design environments (Chapter 7).
- It highlights strategies to negotiate power dynamics, responsibilities, and expertise, promoting effective and balanced interdisciplinary teamwork (Chapter 7 & 8).
- It redefines co-design by demonstrating how it operates as a pedagogical practice to highlight the relational and socio-material interactions among teachers, VIC, designer, and materials (Chapter 8).

I am confident that designers and educators will find in my detailed descriptions practical and inspiring examples of what inclusive and participatory design can achieve. The study translates co-design into lesson compatible routines that teachers can timetable and govern. Short cycles of framing, making, assembly, and reflection align with classroom pacing and responsibilities for care. The work specifies role choreography that includes teacher leadership, children’s graduated autonomy, and bounded support from guardians, and it introduces decision rights mapping so that agency and justification are explicit and reviewable. By carefully documenting co-design practices in authentic educational settings, the thesis provides concrete exemplars of the integration of tactile and interactive materials in learning environments, highlighting new possibilities and actionable strategies that practitioners can adapt to their own contexts. These contributions are not confined to work with VIC. They are applicable to other inclusion contexts such as multilingual classrooms and mixed-ability groups where co-design could operate within ordinary lessons rather than as a special event.

Meanwhile, the thesis advances a stance of vernacularisation that adapts canonical co-design approach to local pedagogic realities while maintaining participatory intent. Methods are treated as hypotheses rather than scripts. Departures from plan are documented as situated knowledge rather than as error, supported by a simple translation log that records what was adapted, retained, or omitted and why. The study also proposes evidence pluralism for school settings. Alongside attainment, practice-proximal indicators such as participation, collaboration, fit to context, and artefact-mediated sense-making are legitimised and routinised through lightweight instruments that can be moderated within or across schools. A decision audit trail links proposals to outcomes and makes the movement of children's and teachers' ideas traceable, an approach that can be taken up in design-based research and in improvement-focused evaluation beyond this setting.

Theoretically, the thesis strengthens a sociomaterial account of co-design as pedagogy by showing how materials mediate participation and concept formation rather than acting only as aids or outputs. Using a CHAT theoretical lens, it demonstrates how contradictions within roles, between rules and tools, and across neighbouring systems act as engines of change in classroom co-design. This explains why some routines stabilise while others stall. The work also challenges the dominance of visual assumptions in design for learning by legitimising multiple representational forms, including tactile, auditory, and spatial-verbal modes, as primary carriers of evidence and instruction. Taken together, these arguments travel beyond the immediate context by offering concepts and exemplars for inclusive multimodal teaching where visual dominance is neither viable nor desirable. Also, the thesis reframes contradictions and historicity as engines of learning through design. By tracing how tensions among rules, tools, and community were surfaced and worked through, the analysis documents expansive moments where the object of activity widened from “making a tactile product” to “re-designing participation and pedagogy” (Engeström & Sannino, 2011, 2021). This provides a portable analytic for co-design projects: map contradictions at multiple levels; use materials to externalise them; and orchestrate iterative trials that convert tensions into redesigned practices.

Overall, the practical, methodological, and theoretical contributions clarify the shift enacted by the thesis. Co-design is framed as pedagogic work under constraint that is governable by teachers, participatory for learners, and evidenced in forms that educators can recognise. The routines, role maps, and evidence practices were developed under conditions common to many systems, including compressed time, heterogeneous cohorts, and strong safety and accountability requirements. They can inform co-design in other high accountability or resource constrained settings such as rural schools, alternative programmes, and vocational learning. Scope conditions are made explicit. Some elements should remain constant, including transparent roles, feasible evidence, and cycles that fit the length of a lesson. Other elements can vary, including themes, materials, and representational modes. This clarity allows educators and designers to adapt with confidence rather than replicate superficially, which in turn extends the work’s relevance well beyond the immediate context of work with VIC in China.

What I would like to emphasise again and most importantly, is that this research provides valuable empirical experience for people who expect or are designing for/with children, especially CwD.

10.3 Limitations

While this thesis has provided valuable insights into co-design as pedagogy and contributed to understanding the complex dynamics of designing educational materials and activities for and with VIC, its exploratory scope entails several limitations that shape how the findings should be read. First, there is the potential for cultural and positional bias. As researcher, designer, and workshop facilitator, I was deeply immersed in the project. To mitigate this, I engaged in continual self-reflection, remained alert to my own assumptions, and avoided inferring intent from behaviour without corroboration (Shai, 2020). I also used triangulation—wherever possible—by validating observations with interviews and video records (Suter, 2012), and sought peer feedback from doctoral colleagues and supervisors. These measures reduced the risk of over-involvement and strengthened trustworthiness, but they do not remove subjectivity entirely.

A second limitation concerns scope and transferability. As explained in Chapter 4, this is a single-site qualitative case with a specific cohort (27 VIC, 8 teachers, 3 experts) in one regional context in China. The findings are therefore closely tied to the socio-cultural and institutional conditions of the site. To support readers' judgments of relevance, I provide thick description of context, participants, methods, and procedures, and I ground the analysis in CHAT to make underlying mechanisms explicit and testable. Even so, broader applicability remains provisional; comparative studies across schools and countries would help assess how context shapes the enactment of co-design as pedagogy and would strengthen generalisability.

Relatedly, a key limitation lies in the evaluation of learning outcomes. The design prioritised understanding processes—how teachers, children, designers, and materials configure participation—rather than testing causal effects on attainment. Time and access constraints meant that workshops and observations occurred within bounded institutional windows and did not span full instructional sequences, precluding robust pre/post assessment or delayed retention checks. As a small, heterogeneous case study, comparison classes or quasi-experimental controls were neither feasible nor desirable without compromising ecological validity. In addition, widely used, visually normed instruments are misaligned with multimodal activity structures and with VIC sensory profiles, and validated curriculum aligned measures for tactile comprehension were not available to this research during fieldwork. For these reasons, the thesis does not make claims about summative academic gains.

In light of these constraints, the evaluation privileged practice-proximal indicators rather than standardised test scores. Evidence focused on children's observable participation and collaboration, the quality and developmental trace of co-produced artefacts relative to task goals, and teacher reflections on instructional uptake and feasibility, triangulated across observations, artefacts, and brief post-activity interviews (as detailed in the Methodology). These choices strengthen ecological validity but do not establish causality; claims are therefore bounded to participation, affordances, and perceived instructional value in context. A complementary programme for strengthening learning evaluation, through longer follow-up, mixed-methods designs, and measures better aligned to tactile and non-visual learning is outlined in the next section.

Finally, communication and interaction with VIC posed practical challenges. The restricted bandwidth of tactile and auditory exchanges, coupled with diverse communicative profiles, made it difficult to capture children's nuanced experiences during design activities. To address these barriers, I combined multiple modalities—tactile, auditory, verbal, and observational—throughout data collection; engaged teachers and guardians who knew each child's communication style; and used repeated interactions and iterative workshops to build familiarity and trust. These measures improved data quality but cannot fully eliminate the risk of partial interpretation. Further understanding could be gained through longitudinal classroom studies and additional parent interviews.

Taken together, these limitations do not diminish the study's contributions; rather, they delimit their scope. The findings should be read as practice grounded insights about co-design as pedagogy in VIC contexts, and as a foundation for future, longer horizon studies capable of assessing learning outcomes more directly.

10.4 Directions

Building upon the insights garnered from this study, several avenues for future research emerge, each poised to deepen our understanding of the intricate dynamics between educators' design strategies and the development of learning materials for VIC. As Dewey emphasised, the fusion of theory and practice is paramount; theoretical advancements in these domains are instrumental in elucidating the relationship between learning materials and activities. Specifically, empirical and conceptual analyses that yield frameworks for delineating and scrutinising the pivotal features and influences within the learning process are vital for addressing our most pressing practical questions. Building on the current findings, three strands of work are indicated.

First, outcome articulation needs to be made explicit at the point of planning co-designed activities. Rather than treating "engagement" or "participation" as catch-all aims, teachers and designers can co-specify short, observable outcomes that blend curriculum goals with accessible practices. For example, concept articulation through non-visual description, part-whole reasoning in a shared artefact, or collaboration moves such as turn-taking and negotiated placement. These outcomes should be written in plain, action-oriented language and mapped to the actual materials and routines used in class. In contexts where Individualised Education Plans are available, alignment of these outcomes to learner specific targets can increase relevance and recognisability for both teachers and families. The present study indicates that when roles and phases are choreographed transparently, teachers are more able to state what success will look like for this activity in this lesson sequence.

Second, outcome assessment should adopt mixed, practice-proximal evidence that is compatible with VIC needs and classroom rhythms. In place of (or alongside) visual normed tests, teachers can use short, repeatable checks embedded in the activity: brief audio explanations of choices, tactile recall/transfer prompts, paired show-and-tell of artefacts, or simple rubrics that rate contribution, collaboration, and concept clarity. Artefact-based portfolios (e.g., photographed stages with captions; audio notes) can provide cumulative evidence across sessions without adding excessive workload. Teacher judgments remain central, but can be stabilised through shared descriptors and moderation within a school or network. Where feasible, pre/post micro-measures that are modality appropriate can complement qualitative traces. The current study's experience with documentation and reflection suggests that such plural evidence can be gathered lightly and still travel into instructional decisions.

Third, study designs should be chosen to strengthen claims about learning while respecting real world constraints. Design based research cycles in partnered classrooms can iterate outcome statements, routines, and evidence tools over multiple lessons, enabling within-class comparisons across iterations. Small comparative pilots can provide contrastive evidence without denying access to activities. Longitudinal case series that follow the same learners across units allow delayed checks on consolidation and transfer. Across these designs, priority should be given to developing or adapting measures that are valid for tactile comprehension and non-visual concept learning, co-created with teachers and specialists.

These strands imply modest but actionable infrastructure at school level: protected time for co-planning outcomes and evidence, simple recording protocols for artefacts and reflections, and light moderation routines. At the systems interface, reporting formats that recognise participation, collaboration, and accessible representation alongside attainment can make co-design evidence visible to educators and families.

Finally, professional learning should move past one-off activity induction toward school embedded cycles where teachers analyse short runs of evidence, adapt materials and roles, and re-specify outcomes accordingly. In sum, the next phase is to keep the practical strengths of co-design as pedagogy—its fit to classroom realities—while building a transparent chain from planned outcomes to feasible evidence, so that educators can both express what they aim to achieve and judge, with effectivity, the extent to which co-design contributes to that learning.

10.5 Thoughts

As designer, the essence of effective design lies not solely in direct product but in the deliberate orchestration of materials that invite exploration, discovery, and self-directed learning. As educators, their role transcends the mere transmission of knowledge; it encompasses the creation of conditions that empower learners to navigate their own educational pathways. The sentiment that the true magic in design and education resides not in our actions alone, but in how we provision environments that set the tone for meaningful learning experiences. In the context of VIC, this entails a deep appreciation for the material qualities of educational tools, an understanding of their interdependencies, and a commitment to nurturing emergent wholeness within the learning process.

This study reaffirms the fundamental right of every individual to access quality education. With the right amalgamation of vision, mission, and hope, educational equity becomes an attainable goal for all. It is my aspiration that this work stands firmly rooted in the rich soil of past scholarship, remains attentively attuned to the realities of the present, and serves as a beacon inspiring readers to reach beyond perceived limitations toward new horizons of possibility. It is not a call for revolutionary change but a gentle reminder of the inherent capacity within each of us to make choices and take actions that promote wholeness and inclusivity in co-design. Every day presents an opportunity to shape learning experiences that honor and uplift the diverse potentials of all children, particularly those who navigate the world without sight.

Co-design beyond Co-design

To move beyond the procedural framing of co-design, it is necessary to consider what kinds of *worlds* these collaborative practices bring into being. As Willis (2006) observes, “ontological designing” refers to the way design continuously shapes human existence and modes of dwelling. In this sense, co-design does not simply solve predefined problems—it reconfigures relations among humans, materials, and institutions, generating new ways of perceiving and enacting reality. The process of making together is also a process of becoming together. Fry (2012) reminds us that design is always future-forming: every designed artefact and system projects a possible world. This realisation obliges co-design to become an ethical and political practice concerned not only with participation, but also with the kinds of futures that participation helps materialise.

From this perspective, co-design can be seen as a form of world building praxis. It transforms those who engage in it, enabling participants to act, perceive, and care differently. Drawing on Dewey’s (1963) notion of experience as transactional, co-design links action and reflection in iterative cycles that cultivate shared inquiry. This aligns with what Escobar (2018) terms *autonomous design*—design that fosters the capacity of communities to determine their own ways of knowing and living, rather than adapting to the logics of global technocapitalism. Autonomous design reframes co-design from a method for inclusion into a mode of *self-determination*: participants co-produce epistemic and material autonomy by re-imagining the infrastructures that shape their lives.

Recent scholarship extends this ontological turn into relational and cosmopolitical directions. Latour (2018) and Puig de la Bellacasa (2017) argue that design must be accountable to the more than human world, acknowledging the agencies of materials, environments, and non-human beings. In this light, co-design is not only an act of social negotiation but also a practice of ecological attunement—a way of composing livable relations among heterogeneous actors. Scholars of design anthropology have similarly described co-design as an "infrastructuring" practice that sustains collective life rather than producing isolated artefacts (Ehn et al., 2014). This perspective helps reveal the latent tension between instrumental co-design (which aims for deliverables) and generative co-design (which aims for enduring relational capacities).

Educational co-design, therefore, can be interpreted as a pedagogy of relation: a process through which participants learn to negotiate meanings, identities, and possibilities within shared material conditions. In this study, the learning activities with visually impaired children exemplify such ontological learning—where tactile and sensory engagement not only facilitate access but also enact new forms of knowing through touch, rhythm, and collective sense-making. This connects to Ingold's (2013) idea of "correspondence," in which thinking and making proceed together as intertwined lines of movement. Co-design thus becomes an epistemic ecology—a distributed field of cognition and care that operates across bodies, materials, and social structures.

This expanded framing positions co-design as a dialogic encounter among worldviews, an inquiry into how humans might live well together. It invites reflection on design's limits: **not every act of inclusion dismantles hierarchy, and not every collaboration transforms structures of inequity**. The challenge is to sustain co-design as an ontological commitment—to cultivate practices that continuously question how designs configure relations of power, participation, and responsibility. Moving forward, engaging with emerging discourses on "design for pluriversality" (Escobar, 2020), "design for care" (Puig de la Bellacasa, 2017), and "design ethics of interdependence" (Fortin et al., 2016) may deepen co-design's potential as a transformative pedagogy and an emancipatory mode of knowledge production.

The Reality, Reimagining, and Rearranging of Co-design

Drawing inspiration from Latour's critique, where he warns against an overly reductionist view of science—criticisms that have been paralleled in educational theories of situated learning—we find that simply deconstructing existing notions is not sufficient. Latour argues that endless revelation and critique of established concepts only serve to entrench divisions rather than build constructive dialogue (Latour, 2004). Similarly, co-design practice can sometimes risk becoming caught in a perpetual cycle of deconstructing traditional top-down design practices, continually revealing participation as idealised or limited. As Pierri (2018) highlights, participatory processes, though ethically admirable and often seen as democratic, can paradoxically reinforce existing power imbalances, creating illusionary or performative modes of participation rather than truly transformative engagements. Therefore, co-design does not occur in an idealised vacuum but within the lived experience of individuals and communities marked by complexities, hierarchies, and power dynamics. Hyysalo and Hyysalo (2018) further emphasise that co-design processes are inherently strategic and mundane, filled with subtle negotiations, compromises, and everyday complexities that are often overlooked when participation is idealized. Thus, acknowledging this nuanced reality is foundational if co-design practices are to move beyond surface participation toward genuine engagement and empowerment.

To move beyond critique, co-design must be actively reimagined. Co-design can be reconceived not simply as an inclusive practice, but as a form of pluralistic enactment of diverse realities. It is precisely this multiplicity of forms that facilitates a broader conceptualisation of knowledge, learning, material, technology, and agency in co-design contexts. In VIC educational settings especially, recognising this multiplicity allows for the reimagining of activity, participation, and agency beyond established or singular pedagogical traditions. This reimagining invokes the ideas of emergence and relationality. In this view, knowledge and learning are not fixed entities waiting to be discovered or transferred; rather, they are dynamic, emergent outcomes of ongoing interactions between participants, materials, environments, and ideas. Thus, co-design is more meaningfully understood as a space for the emergence of new relationalities, where roles, meanings, and identities are continually negotiated and reshaped.

We could rearrange co-design follows logically from reimagining it. Philosophically, rearranging is not merely about practical adjustments, but rather about systematically altering the relational patterns and power structures within co-design practices. This aligns closely with Latour's argument against simplistic redefinitions. As Sørensen (2009) asserts, recognising multiplicity inherently opens opportunities for rearrangement; once we discern different patterns of relationality, we can strategically rearrange these relationships and entities to forge new connections and possibilities for transformation. In this research, rearranging involves active, reflective interventions that consciously alter relationships, redistribute authority, and cultivate new forms of participation. It moves beyond mere methodological adjustments and demands systemic transformations that empower traditionally marginalised participants, thereby ensuring that their lived experiences, epistemologies, and values actively shape design outcomes. Hyysalo and Hyysalo (2018) further reinforce that meaningful rearrangements often emerge from mundane strategic actions—small-scale, seemingly trivial decisions about who participates, how participation is structured, and whose voices and experiences are prioritised. Attention to these mundane elements is significant, highlighting that profound shifts in co-design occur precisely through subtle, incremental rearrangements of roles, expectations, and processes.

Ultimately, co-design cultivates sensitivity, embracing the complexity of reality, deliberately reimagining possibilities, and thoughtfully rearranging relational structures. In doing so, we acknowledge the performative nature of knowledge and learning highlighted by Sørensen, while also moving beyond Latour's critique of endless deconstruction. This sensitivity aligns with a Deweyan pragmatist approach, reminding us that theoretical progress must serve practical improvement and vice versa. Co-design becomes more than an ideal—it transforms into a lived philosophical practice that continually seeks to deepen democratic participation, equity, and inclusivity, reshaping not just design outcomes but the relational and ontological landscapes within which co-design is enacted.

10.6 Epilogue

In closing, I wish to return to the motivation that inspired this research. Throughout the process of understanding VIC, I have occupied the roles of both outsider and researcher. The complex tensions involving PVI's own expectations, society's low expectations toward them, and the constraints of available resources formed a knot that tightened around me. Rather than adopting a motivational or exemplary approach to design, we have a greater responsibility to genuinely see the PVI themselves and the specific struggles they face or have endured.

PVI frequently encounter significant challenges in obtaining equitable educational opportunities. Beyond visual impairments themselves, these difficulties predominantly result from neglect in social support structures. Nevertheless, it is essential to recognise that disability is not a fixed identity but a fluid state. Given the relative scarcity of design and support for VIC, greater individual initiative is required. When we begin to act, we quickly realise that even small steps forward can unlock substantial possibilities.

It is difficult to pinpoint the exact moment when these actions began. Perhaps it was when I made my first call to the parent of a visually impaired child, submitted my first manuscript related to design for VIC, or perhaps even when I inadvertently clicked on a news article. However, the end of this research is certainly not the endpoint. My hope is that researchers, at the conclusion of their studies—or indeed at any moment—will continue to believe in the power of action and retain a desire to effect change. I also hope this research makes future journeys easier, requiring less effort and energy. The road less traveled especially demands tactile paving—not merely because there is no one available to guide them, but because doing so helps those who follow navigate more convenient.

References

Abbas, R., Tootell, H., Freeman, M., & Ellmers, G. (2018). Engaging Young Children as Application Design Partners: A Stakeholder-Inclusive Methodological Approach. In *IEEE technology & society magazine* (Vol. 37, Number 3, pp. 38–47). IEEE. https://doi.org/10.1109/MTS.2018.2857584

Adebisi, R. O., Liman, N. A., & Longpoe, P. K. (2015). Using assistive technology in teaching children with learning disabilities in the 21st century. *Journal of Education and Practice, 6*(24), 14-20.

Adedoyin, O. B., & Soykan, E. (2023). Covid-19 pandemic and online learning: the challenges and opportunities. *Interactive Learning Environments, 31*(2), 863–875. https://doi.org/10.1080/10494820.2020.1813180

Adefila, A., Broughan, C., Phimister, D., & Opie, J. (2020). Developing an autonomous-support culture in higher education for disabled students. *Disability and Health Journal, 13*(3), 100890–100890. https://doi.org/10.1016/j.dhjo.2020.100890

Agustin, M., Chuang, G., Delgado, A., Ortega, A., Seaver, J., & Buchanan, J. W. (2007). Game sketching. *ACM International Conference Proceeding Series, 274*, 36–43. https://doi.org/10.1145/1306813.1306855

Aitchison, C., Harper, R., Mirriahi, N., & Guerin, C. (2020). Tensions for educational developers in the digital university: developing the person, developing the product. *Higher Education Research and Development, 39*(2), 171–184. https://doi.org/10.1080/07294360.2019.1663155

Akkerman, S. F., & Bakker, A. (2011). Boundary Crossing and Boundary Objects. *Review of Educational Research, 81*(2), 132–169. https://doi.org/10.3102/0034654311404435

Albrahim, F.A.M. (2018) *Go Hand in Hand: A Case Study in the Collaboration between Faculty and Instructional Designers when Developing Online Courses*. PhD thesis. Ohio University.

Aldrich, F. K., & Sheppard, L. (2001). Tactile graphics in school education: perspectives from pupils. *The British Journal of Visual Impairment, 19*(2), 69–73. https://doi.org/10.1177/026461960101900204

Alper, M., & Goggin, G. (2017). Digital technology and rights in the lives of children with disabilities. *New Media & Society, 19*(5), 726–740. https://doi.org/10.1177/1461444816686323

Alshenqeeti, H. (2014). Interviewing as a data collection method: A critical review. *English linguistics research, 3*(1), 39-45.

Anastasiou, E., & Hajisoteriou, C. (2022). Enhancing inclusion through the collective activity of collaboration: a cultural historical activity theory perspective. *Research Papers in Education, 37*(2), 275–301. https://doi.org/10.1080/02671522.2020.1849368

Anticoli, L., & Toppano, E. (2011). How Culture May Influence Ontology Co-Design: A Qualitative Study. *International Journal of Information Technology and Web Engineering, 6*(2), 1–17. https://doi.org/10.4018/jitwe.2011040101

Artiles, A. J. (2019). Fourteenth Annual Brown Lecture in Education Research: Reenvisioning Equity Research: Disability Identification Disparities as a Case in Point. *Educational Researcher, 48*(6), 325–335. https://doi.org/10.3102/0013189X19871949

Arturo E. (2018). *Designs for the Pluriverse: Radical Interdependence, Autonomy, and the Making of Worlds*. Duke University Press. https://doi.org/10.1215/9780822371816

Asensio-Pérez, J. I., Dimitriadis, Y., Pozzi, F., Hernández-Leo, D., Prieto, L. P., Persico, D., & Villagrá-Sobrino, S. L. (2017). Towards teaching as design: Exploring the interplay between full-lifecycle learning design tooling and Teacher Professional Development. *Computers and Education, 114*, 92–116. https://doi.org/10.1016/j.compedu.2017.06.011

Baibarac, C., & Petrescu, D. (2019). Co-design and urban resilience: visioning tools for commoning resilience practices. *CoDesign, 15*(2), 91–109. https://doi.org/10.1080/15710882.2017.1399145

Bakhurst, D. (2009). Reflections on activity theory. *Educational Review (Birmingham), 61*(2), 197–210. https://doi.org/10.1080/00131910902846916

Bakx, A., Bakker, A., Koopman, M., & Beijaard, D. (2016). Boundary crossing by science teacher researchers in a PhD program. *Teaching and Teacher Education, 60*, 76–87. https://doi.org/10.1016/j.tate.2016.08.003

Bal, A. (2018). Culturally responsive positive behavioral interventions and supports: A process–oriented framework for systemic transformation. *The Review of Education/Pedagogy/Cultural Studies, 40*(2), 144–174. https://doi.org/10.1080/10714413.2017.1417579

Bal, A., Waitoller, F. R., Mawene, D., & Gorham, A. (2021). Culture, context, and disability: A systematic literature review of cultural-historical activity theory-based studies on the teaching and learning of students with disabilities. *The Review of Education/Pedagogy/Cultural Studies, 43*(4), 293–337. https://doi.org/10.1080/10714413.2020.1829312

Balchin, W. G. V. (1985). Graphicacy Achieves Examination Status. *Area (London 1969), 17*(3), 256–256.

Barab, S., & Squire, K. (2004). Design-Based Research: Putting a Stake in the Ground. *The Journal of the Learning Sciences, 13*(1), 1–14. https://doi.org/10.1207/s15327809jls1301_1

Barendregt, W., Bekker, T. M., Börjesson, P., Eriksson, E., & Torgersson, O. (2016). Legitimate participation in the classroom context: Adding learning goals to participatory design. In *Proceedings of the the 15th international conference on interaction design and children* (pp. 167-174). https://doi.org/10.1145/2930674.2930686

Barnard, M. (2005). *Graphic design as communication* (1st ed.). Routledge. https://doi.org/10.4324/9781315015385

Barth, J. L. (1982). The Development and Evaluation of a Tactile Graphics Kit. *Journal of Visual Impairment & Blindness, 76*(7), 269–273. https://doi.org/10.1177/0145482X8207600704

Barvir, R., Vondrakova, A., & Brus, J. (2021). Efficient Interactive Tactile Maps: A Semi-Automated Workflow Using the TouchIt3D Technology and OpenStreetMap Data. *ISPRS International Journal of Geo-Information, 10*(8), 505-. https://doi.org/10.3390/ijgi10080505

Bayerlein, L., & McGrath, N. (2018). Collaborating for success: an analysis of the working relationship between academics and educational development professionals. *Studies in Higher Education (Dorchester-on-Thames), 43*(6), 1089–1106. https://doi.org/10.1080/03075079.2016.1215417

Bell, E. C., & Silverman, A. M. (2018). The Impact of Attitudes and Access to Mentors on the Interest in STEM for Teens and Adults who are Blind. *Journal of Blindness Innovation and Research, 8*(2). https://doi.org/10.5241/8-154

Benade, L. (2019). Flexible Learning Spaces: Inclusive by Design? *New Zealand Journal of Educational Studies, 54*(1), 53–68. https://doi.org/10.1007/s40841-019-00127-2

Bennett, S., Maton, K., & Kervin, L. (2008). The "digital natives" debate: A critical review of the evidence. *British Journal of Educational Technology, 39*(5), 775–786. https://doi.org/10.1111/j.1467-8535.2007.00793.x

Benton, S. A. (1984). Supporting visually handicapped children in ordinary schools. *British Journal of Visual Impairment, 2*, 3-7.

Berg, B. L. (Bruce L. (2004). *Qualitative research methods for the social sciences* (5th ed.). Pearson.

Berger, P. L., & Luckmann, T. (1966). *The social construction of reality : a treatise in the sociology of knowledge*. Doubleday.

Bergström, J., Clark, B., Frigo, A., Mazé, R., Redström, J., & Vallgårda, A. (2010). Becoming materials: material forms and forms of practice. *Digital Creativity (Exeter), 21*(3), 155–172. https://doi.org/10.1080/14626268.2010.502235

Bernstein, B. (2000). *Pedagogy, symbolic control, and identity : theory, research, critique* (Rev. ed.). Rowman & Littlefield Publishers.

Bevan Jones, R., Stallard, P., Agha, S. S., Rice, S., Werner-Seidler, A., Stasiak, K., Kahn, J., Simpson, S. A., Alvarez-Jimenez, M., Rice, F., Evans, R., & Merry, S. (2020). Practitioner review: Co-design of digital mental health technologies with children and young people. *Journal of Child Psychology and Psychiatry, 61*(8), 928–940. https://doi.org/10.1111/jcpp.13258

Biederman, I. (1987). Recognition-by-Components: A Theory of Human Image Understanding. *Psychological Review, 94*(2), 115–147. https://doi.org/10.1037/0033-295X.94.2.115

Bishop, F., Zagermann, J., Pfeil, U., Sanderson, G., Reiterer, H., & Hinrichs, U. (2020). Construct-A-Vis: Exploring the Free-Form Visualization Processes of Children. *IEEE Transactions on Visualization and Computer Graphics, 26*(1), 451–460. https://doi.org/10.1109/TVCG.2019.2934804

Bishop, V. E. (2004). *Teaching visually impaired children* (3rd ed.). Charles C Thomas.

Black-Hawkins, K., Florian, L. & Rouse, M. (2009). Inclusive pedagogy and children's achievement. In *European Conference for Educational Research*, Vienna, 25-26.

Bligh, B., & Flood, M. (2017). Activity theory in empirical higher education research: choices, uses and values. *Tertiary Education and Management, 23*(2), 125–152. https://doi.org/10.1080/13583883.2017.1284258

Boichenko, M. I. (2021). Human Evolution: the Limits of Technocentrism. *Antropologìnì Vimìri Filosofs'kih Doslìden', 19*, 15–22. https://doi.org/10.15802/ampr.v0i19.235956

Boland, R. J., Collopy, F., Lyytinen, K., & Yoo, Y. (2008). Managing as Designing: Lessons for Organization Leaders from the Design Practice of Frank O. Gehry. *Design Issues, 24*(1), 10–25. https://doi.org/10.1162/desi.2008.24.1.10

Bolster, E. A. M., Gessel, C. van, Welten, M., Hermsen, S., Lugt, R. van der, Kotte, E., Essen, A. van, & Bloemen, M. A. T. (2021). Using a Co-design Approach to Create Tools to Facilitate Physical Activity in Children With Physical Disabilities. *Frontiers in Rehabilitation Sciences*, *2*, 707612 – 707612. https://doi.org/10.3389/fresc.2021.707612

Boud, D. (1988). *Developing student autonomy in learning* (2nd ed.). Kogan Page.

Bourdieu, P. (1977). *Outline of a theory of practice*. Cambridge University Press.

Bourdieu, P. (1990). *The logic of practice*. Polity Press.

Bowler, L., Wang, K., Lopatovska, I., & Rosin, M. (2021). The meaning of "Participation" in co-design with children and youth: relationships, roles, and interactions. *Proceedings of the Association for Information Science and Technology, 58*(1), 13-24. https://doi.org/10.1002/pra2.432

Bozalek, V. (2015). *Activity theory, authentic learning and emerging technologies : towards a transformative higher education pedagogy*. Routledge. https://doi.org/10.4324/9781315771823

Braier, J., Lattenkamp, K., Räthel, B., Schering, S., Wojatzki, M., & Weyers, B. (2015). Haptic 3D surface representation of table-based data for people with visual impairments. *ACM Transactions on Accessible Computing, 6*(1), 1–35. https://doi.org/10.1145/2700433

Braille Authority of North America (BANA). (2010). Guidelines and Standards for Tactile Graphics, Vol. 2010.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Braun, V., & Clarke, V. (2019). Reflecting on reflexive thematic analysis. *Qualitative Research in Sport, Exercise and Health, 11*(4), 589–597. https://doi.org/10.1080/2159676X.2019.1628806

Braun, V., & Clarke, V. (2020). One size fits all? What counts as quality practice in (reflexive) thematic analysis? *Qualitative Research in Psychology, 18*(3), 328–352. https://doi.org/10.1080/14780887.2020.1769238

Brondino, M., Dodero, G., Gennari, R., Melonio, A., Pasini, M., Raccanello, D., Torello, S., Vittorini, P., Mascio, T. D., & de la Prieta, F. (2015). Emotions and Inclusion in Co-design at School:Let's Measure Them. In *Advances in Intelligent Systems and Computing* (Vol. 374, pp. 1–8). Springer International Publishing AG. https://doi.org/10.1007/978-3-319-19632-9_1

Brown, J. E., & Beamish, W. (2012). The Changing Role and Practice of Teachers of Students with Visual Impairments: Practitioners' Views from Australia. *Journal of Visual Impairment & Blindness, 106*(2), 81–92. https://doi.org/10.1177/0145482X1210600203

Brown, L. R., Sullivan, F., Treweek, S., Haddow, A., Mountain, R., Selby, C., & Beusekom, M. van. (2022). Increasing uptake to a lung cancer screening programme: building with communities through co-design. *BMC Public Health, 22*(1), 815–815. https://doi.org/10.1186/s12889-022-12998-0

Buchanan, R. (1992). Wicked Problems in Design Thinking. *Design Issues, 8*(2), 5–21. https://doi.org/10.2307/1511637

Bullinger, A. C., Neyer, A.-K., Rass, M., & Moeslein, K. M. (2010). Community-Based Innovation Contests: Where Competition Meets Cooperation. *Creativity and Innovation Management, 19*(3), 290–303. https://doi.org/10.1111/j.1467-8691.2010.00565.x

Bushin, N. (2007). Interviewing with Children in their Homes: Putting Ethical Principles into Practice and Developing Flexible Techniques. *Children's Geographies, 5*(3), 235–251. https://doi.org/10.1080/14733280701445796

Butler, T., Gall, A., Garvey, G., Ngampromwongse, K., Hector, D., Turnbull, S., Lucas, K., Nehill, C., Boltong, A., Keefe, D., & Anderson, K. (2022). A Comprehensive Review of Optimal Approaches to Co-Design in Health with First Nations Australians. *International Journal of Environmental Research and Public Health, 19*(23), 16166-. https://doi.org/10.3390/ijerph192316166

Callen, J. C., & Austin, E. K. (2016). Deterritorializing Utopia: The Possibility of Techno-Utopias in Societies of Control. *Administrative Theory & Praxis, 38*(1), 19–36. https://doi.org/10.1080/10841806.2015.1128220

Calvo, M., & Sclater, M. (2021). Creating Spaces for Collaboration in Community Co-design. *The International Journal of Art & Design Education, 40*(1), 232–250. https://doi.org/10.1111/jade.12349

Cappiali, T. M. (2023). A Paradigm Shift for a More Inclusive, Equal, and Just Academia? Towards a Transformative-Emancipatory Pedagogy. *Education Sciences, 13*(9), 876-. https://doi.org/10.3390/educsci13090876

Carbonell, K. B., Dailey-Hebert, A., & Gijselaers, W. (2013). Unleashing the creative potential of faculty to create blended learning. *The Internet and Higher Education, 18*, 29–37. https://doi.org/10.1016/j.iheduc.2012.10.004

Carroll, M., Goldman, S., Britos, L., Koh, J., Royalty, A., & Hornstein, M. (2010). Destination, Imagination and the Fires Within: Design Thinking in a Middle School Classroom. *The International Journal of Art & Design Education, 29*(1), 37–53. https://doi.org/10.1111/j.1476-8070.2010.01632.x

Castañer, X., & Oliveira, N. (2020). Collaboration, Coordination, and Cooperation Among Organizations: Establishing the Distinctive Meanings of These Terms Through a Systematic Literature Review. *Journal of Management, 46*(6), 965–1001. https://doi.org/10.1177/0149206320901565

Cavazos Quero, L., Iranzo Bartolomé, J., & Cho, J. (2021). Accessible visual artworks for blind and visually impaired people: Comparing a multimodal approach with tactile graphics. *Electronics (Basel), 10*(3), 1–19. https://doi.org/10.3390/electronics10030297

Cavdir, D. (2022). Touch, listen,(re) act: Co-designing vibrotactile wearable instruments for deaf and hard of hearing. In *NIME 2022*. PubPub.

Chen, X., Wang, L., & Wang, Z. (2009). Shyness-Sensitivity and Social, School, and Psychological Adjustment in Rural Migrant and Urban Children in China. *Child Development, 80*(5), 1499–1513. https://doi.org/10.1111/j.1467-8624.2009.01347.x

Cheng, Y., & Hamid, M. O. (2025). Social impact of Gaokao in China: a critical review of research. *Language Testing in Asia, 15*(1), Article 22. https://doi.org/10.1186/s40468-025-00355-y

Chilisa, B., & Kawulich, B. B. (2012). Selecting a research approach: paradigm, methodology and methods. Doing Social Research, A Global Context. In C. Wagner, B. Kawulich, & M. Garner (Eds.), *Doing soical research: A global context* (pp. 51–61). McGraw-Hill.

Christensen, P. & James, A. (2000). Children as Respondents: The Challenge for Quantitative Methods. In *Research With Children* (pp. 110–131). Routledge. https://doi.org/10.4324/9780203024607-11

Clark, C. D. (2011). *In a younger voice doing child-centered qualitative research*. Oxford University Press.

Clarke, V., & Braun, V. (2017). Thematic analysis. *The Journal of Positive Psychology, 12*(3), 297–298. https://doi.org/10.1080/17439760.2016.1262613

Clarkson, J. J., Janiszewski, C., & Cinelli, M. D. (2013). The Desire for Consumption Knowledge. *The Journal of Consumer Research, 39*(6), 1313–1329. https://doi.org/10.1086/668535

Clegg, J. W., Slife, B. D., Mertens, D. M., & Ginsberg, P. E. (2009). Research Ethics in the

Postmodern Context. In *The Handbook of Social Research Ethics* (pp. 23–38). SAGE Publications, Inc. https://doi.org/10.4135/9781483348971.n2

Clifford, S. (2022). The use and value of cultural historical activity theory in institutional educational technology policy. *Studies in Technology Enhanced Learning, 3*(1).

Cohen, L., Manion, L., Morrison, K., Bell, R., ProQuest, & Morrison, K. (Keith R. B.). (2011). *Research methods in education* (7th ed.). Routledge.

Cole, M. & Engeström, Y. (1993) A cultural-historical approach to distributed cognition. In *Distributed cognitions: Psychological and educational considerations*. Cambridge University Press, pp. 1 – 46.

Cole, M. (1988). Cross-Cultural Research in the Sociohistorical Tradition. *Human Development, 31*(3), 137–152. https://doi.org/10.1159/000275803

Cole, M. (2013). Cognitive development and formal schooling: The evidence from cross-cultural research. In *Learning Relationships in the Classroom* (pp. 31–53).

Collins, A., & Halverson, R. (2018). *Rethinking education in the age of technology : the digital revolution and schooling in America* (Second edition.). Teachers College Press.

Collyer, F. M. (2015). Practices of conformity and resistance in the marketisation of the academy: Bourdieu, professionalism and academic capitalism. *Critical Studies in Education, 56*(3), 315–331. https://doi.org/10.1080/17508487.2014.985690

Conole, G., & Dalziel, J. (2016). Theoretical Underpinnings of Learning Design. In *Learning Design* (1st ed., pp. 42–62). Routledge. https://doi.org/10.4324/9781315693101-2

Cook-Sather, A. (2014). Student-faculty partnership in explorations of pedagogical practice: a threshold concept in academic development. *The International Journal for Academic Development, 19*(3), 186–198. https://doi.org/10.1080/1360144X.2013.805694

Crawford, K., & Hasan, H. (2006). Demonstrations of the Activity Theory Framework for Research in Information Systems. *Australasian Journal of Information Systems, 13*(2). https://doi.org/10.3127/ajis.v13i2.40

Creswell, J. W. (2013). *Qualitative inquiry and research design : choosing among five approaches* (3rd ed.). SAGE Publications.

Creswell, J. W. (2014). *Research design : qualitative, quantitative, and mixed methods approaches* (4th ed.). SAGE Publications.

Cross, N. (2001). Designerly Ways of Knowing: Design Discipline versus Design Science.

Design Issues, 17(3), 49–55. https://doi.org/10.1162/074793601750357196

Cross, N. (2006). *Designerly ways of knowing* (1st ed. 2006.). Springer. https://doi.org/10.1007/1-84628-301-9

Crotty, M. (1998). *The foundations of social research : meaning and perspective in the research process*. Allen & Unwin.

Daniels, H. (2004). Cultural historical activity theory and professional learning. International *Journal of Disability, Development, and Education, 51*(2), 185–200. https://doi.org/10.1080/10349120410001687391

Daugherty, W. (2014). A Brief History of how and Why the Texas School for the Blind and Visually Impaired Developed Its Diversified Model of Service Delivery. *Journal of Visual Impairment & Blindness, 108*(6), 487–491. https://doi.org/10.1177/0145482X1410800606

Decarlo, D. K., McGwin, G., Bixler, M. L., Wallander, J., & Owsley, C. (2012). Impact of pediatric vision impairment on daily life: Results of focus groups. *Optometry and Vision Science, 89*(9), 1409–1416. https://doi.org/10.1097/OPX.0b013e318264f1dc

Dello-Iacovo, B. (2009). Curriculum reform and 'Quality Education' in China: An overview. *International Journal of Educational Development, 29*(3), 241 – 249. https://doi.org/10.1016/j.ijedudev.2008.02.008

Deng, M., & Poon-McBrayer, K. F. (2012). Reforms and challenges in the era of inclusive education: the case of China. *British Journal of Special Education, 39*(3), 117 – 122. https://doi.org/10.1111/j.1467-8578.2012.00551.x

Denscombe, M. (2007). *Good Research Guide* (1st ed.). McGraw-Hill Education.

Dewey, J. (1958). *Experience and nature* (2nd ed.). Dover.

Dewey, J. (1963). *Experience and education*. Collier.

Dewey, J., & Boydston, J. A. (1981). *The later works*, *1925-1953*. Southern Illinois University Press.

Dillenbourg, P. (2013). Design for classroom orchestration. *Computers and Education*, *69*, 485–492. https://doi.org/10.1016/j.compedu.2013.04.013

Dinham, S. M. (1989). Teaching as design: theory, research and implications for design teaching. *Design Studies, 10*(2), 80–88. https://doi.org/10.1016/0142-694X(89)90040-9

Dodero, G., Gennari, R., Melonio, A., & Torello, S. (2014). Towards tangible gamified co-design at school: two studies in primary schools. *CHI PLAY 2014 - Proceedings of the 2014 Annual Symposium on Computer-Human Interaction in Play*, 77–86. https://doi.org/10.1145/2658537.2658688

Dorst, K. (2004). On the problem of design problems-problem solving and design expertise. *Journal of design research, 4*(2), 185-196.

Dorst, K. (2019). Design beyond Design. *She Ji: The Journal of Design, Economics and Innovation, 5*(2), 117–127. https://doi.org/10.1016/j.sheji.2019.05.001

Dorta, T., Kalay, Y., Lesage, A., & Pérez, E. (2011). Design conversations in the interconnected HIS. *International Journal of Design Sciences and Technology, 18*(2), 65-80.

Downton, P. (2003). *Design research*. RMIT Publishing.

Drain, A., & Sanders, E. B. N. (2019). A collaboration system model for planning and evaluating participatory design projects. *International Journal of Design, 13*(3), 39–52.

Drain, A., Shekar, A., & Grigg, N. (2018). Participatory Design with People with Disability in Rural Cambodia: The Creativity Challenge. *The Design Journal, 21*(5), 685–706. https://doi.org/10.1080/14606925.2018.1488923

Drysdale, J. T. (2019). The Collaborative Mapping Model: Relationship-Centered Design for Higher Education. *Online Learning (Newburyport, Mass.), 23*(3). https://doi.org/10.24059/olj.v23i3.2058

Ducasse, J., Brock, A. M., Jouffrais, C., Velazquez, R., Pissaloux, E., Velazquez, R., & Pissaloux, E. (2018). Accessible Interactive Maps for Visually Impaired Users. In *Mobility of Visually Impaired People* (pp. 537–584). Springer International Publishing AG. https://doi.org/10.1007/978-3-319-54446-5_17

Durall, E., Bauters, M., Hietala, I., Leinonen, T., & Kapros, E. (2019). Co-creation and co-design in technology-enhanced learning: Innovating science learning outside the classroom. *Interaction Design & Architecture(s), 42*(42), 202–226. https://doi.org/10.55612/s-5002-042-010

Ehn, P., Nilsson, E. M., & Topgaard, R. (Eds.). (2014). *Making futures : marginal notes on innovation, design, and democracy* (1st ed.). The MIT Press.

Einarsdottir, J. (2007). Research with children: methodological and ethical challenges. *European Early Childhood Education Research Journal, 15*(2), 197–211. https://doi.org/10.1080/13502930701321477

Eisner, E. W. (1983). The Art and Craft of Teaching. In *Educational leadership* (Vol. 40, Number 4, pp. 4-). National Education Association, Dept. of Supervision and Curriculum Development.

Eladhari, M. P., & Ollila, E. M. I. (2012). Design for Research Results: Experimental Prototyping and Play Testing. *Simulation & Gaming, 43*(3), 391–412. https://doi.org/10.1177/1046878111434255

Ellsworth, E. (2005). The Materiality of Pedagogy: Sensations Crucial to Understandings. In *Places of Learning* (1st ed., pp. 15–36). Routledge.

Ely, M. S., & Ostrosky, M. M. (2017). Survey Results for Training and Resource Needs Cited by Early Intervention Professionals in the Field of Visual Impairment. *Journal of Visual Impairment & Blindness, 111*(6), 527–542. https://doi.org/10.1177/0145482X1711100604

Engel, C., & Weber, G. (2017). Improve the accessibility of tactile charts. In *Human-Computer Interaction-INTERACT 2017: 16th IFIP TC 13 International Conference, Mumbai, India, September 25–29, 2017, Proceedings, Part I 16* (pp. 187-195). Springer International Publishing.

Engel, C., Weber, G., Petrie, H., Loizides, F., Winckler, M., Zaphiris, P., Nacke, L., Lamas, D., Winckler, M., Zaphiris, P., Petrie, H., Loizides, F., Nacke, L., & Lamas, D. (2019). User Study: A Detailed View on the Effectiveness and Design of Tactile Charts. In *Human-Computer Interaction - INTERACT 2019* (Vol. 11746, pp. 63–82). Springer International Publishing AG. https://doi.org/10.1007/978-3-030-29381-9_5

Engeström, Y. (1987) *Learning by expanding: An activity-theoretical approach to developmental research*. Helsinki, Finland: Orienta-Konsultit.

Engeström, Y. (1999). Activity theory and individual and social transformation. *Perspectives on activity theory. 19* (38), 19–30.

Engeström, Y. (2001). Expansive Learning at Work: Toward an activity theoretical reconceptualization. *Journal of Education and Work, 14*(1), 133–156. https://doi.org/10.1080/13639080020028747

Engeström, Y. (2008) *From teams to knots: activity-theoretical studies of collaboration and learning at work*. Cambridge, Cambridge University Press.

Engeström, Y. (2015). *Learning by expanding : an activity-theoretical approach to developmental research* (Second edition.). Cambridge University Press.

Engeström, Y., & Sannino, A. (2010). Studies of expansive learning: Foundations, findings and future challenges. *Educational Research Review, 5*(1), 1–24. https://doi.org/10.1016/j.edurev.2009.12.002

Engeström, Y., & Sannino, A. (2011). Discursive manifestations of contradictions in organizational change efforts: A methodological framework. *Journal of Organizational Change Management, 24*(3), 368–387. https://doi.org/10.1108/09534811111132758

Engeström, Y., & Sannino, A. (2021). From mediated actions to heterogenous coalitions: four generations of activity-theoretical studies of work and learning. *Mind, Culture and Activity, 28*(1), 4–23. https://doi.org/10.1080/10749039.2020.1806328

Erin, J. N. (2014). Building on Existing Resources to Create New Learning Options for Students with Visual Impairments. *Journal of Visual Impairment & Blindness, 108*(6), 485–487. https://doi.org/10.1177/0145482X1410800605

Escobar, A. (2018). *Designs for the pluriverse : radical interdependence, autonomy, and the making of worlds*. Duke University Press. http://dx.doi.org/10.1215/9780822371816

Escobar, A. (2020). *Pluriversal politics : the real and the possible*. Duke University Press. http://dx.doi.org/10.1215/9781478012108

Evans, S. (1996). The context of English language education the case of Hong Kong. *Relc Journal, 27*(2), 30-55. https://doi.org/10.1177/003368829602700203

Fagliano, P. (1998). Students with a vision impairment. In *Educating children with special needs* (3rd ed.). Sydney: Prentice Hall.

Fajri, Z., Baharun, H., Muali, C., Shofiatun, Farida, L., & Wahyuningtiyas, Y. (2021). Student's Learning Motivation and Interest; The Effectiveness of Online Learning during COVID-19 Pandemic. *Journal of Physics: Conference Series, 1899*(1), 12178-. https://doi.org/10.1088/1742-6596/1899/1/012178

Fan, D., Fay Siu, A., O'Modhrain, S., Follmer, S., Guerreiro, T., Moffatt, K., & Nicolau, H. (2020). Constructive Visualization to Inform the Design and Exploration of Tactile Data Representations. *ASSETS 2020 - 22nd International ACM SIGACCESS Conference on Computers and Accessibility*, 1–4. https://doi.org/10.1145/3373625.3418027

Fenwick, T., Nerland, M., & Jensen, K. (2012). Sociomaterial approaches to conceptualising professional learning and practice. *Journal of Education and Work, 25*(1), 1–13. https://doi.org/10.1080/13639080.2012.644901

Fereday, J., & Muir-Cochrane, E. (2006). Demonstrating Rigor Using Thematic Analysis: A Hybrid Approach of Inductive and Deductive Coding and Theme Development.

International Journal of Qualitative Methods, 5(1), 80–92. https://doi.org/10.1177/160940690600500107

Ferrell, K. A. (1998). Project PRISM: A longitudinal study of developmental patterns of children who are visually impaired. (Final report). Greeley's Division of Special Education, University of Northern Colorado.

Fischer, B., Östlund, B., Dalmer, N. K., Rosales, A., Peine, A., Loos, E., Neven, L., & Marshall, B. (2021). Co-design as learning: The differences of learning when involving older people in digitalization in four countries. *Societies (Basel, Switzerland), 11*(2), 66-. https://doi.org/10.3390/soc11020066

Fischer, B., Östlund, B., Zhou, J., & Gao, Q. (2020). Technology Development with Older People: The Role of "Unfettered Design." In *Human Aspects of IT for the Aged Population. Technologies, Design and User Experience* (Vol. 12207, pp. 18–33). Springer International Publishing AG. https://doi.org/10.1007/978-3-030-50252-2_2

Fjeld, M., Lauche, K., Bichsel, M., Voorhorst, F., Krueger, H., & Rauterberg, M. (2002). Physical and virtual tools: Activity theory applied to the design of groupware. *Computer Supported Cooperative Work, 11*(1 – 2), 153 – 180. https://doi.org/10.1023/A:1015269228596

Fletcher, A. (2024). And (epistemic) justice for all: a cautionary tale of knowledge inequality in participatory research. *Quality in Ageing, 25*(1), 68–79. https://doi.org/10.1108/QAOA-03-2023-0021

Florian, L., & Black-Hawkins, K. (2011). Exploring inclusive pedagogy. *British Educational Research Journal, 37*(5), 813–828. https://doi.org/10.1080/01411926.2010.501096

Florian, L., & Linklater, H. (2010). Preparing teachers for inclusive education: using inclusive pedagogy to enhance teaching and learning for all. *Cambridge Journal of Education, 40*(4), 369–386. https://doi.org/10.1080/0305764X.2010.526588

Foote, M. Q., & Bartell, T. G. (2011). Pathways to equity in mathematics education: how life experiences impact researcher positionality. *Educational Studies in Mathematics, 78*(1), 45–68. https://doi.org/10.1007/s10649-011-9309-2

Fortin, M., Nadisic, T., Bell, C. M., Crawshaw, J. R., & Cropanzano, R. (2016). Beyond the Particular and Universal: Dependence, Independence, and Interdependence of Context, Justice, and Ethics. *IDEAS Working Paper Series from RePEc, 137*(4), 639 – 647. https://doi.org/10.1007/s10551-015-2823-x

Fraser-Barbour, E., Robinson, S., Gendera, S., Burton-Clark, I., Fisher, K. R., Alexander, J., & Howe, K. (2023). Shifting power to people with disability in co-designed research.

Disability & Society, 1 – 22. https://doi.org/10.1080/09687599.2023.2279932

Freire, P. (1970). *Pedagogy of the oppressed*. Herder and Herder.

Friesike, S., & Bartling, S. (2014). Open Science: One Term, Five Schools of Thought. In *Opening Science*. Springer International Publishing AG.

Fugate, J. M. B., Macrine, S. L., & Cipriano, C. (2019). The role of embodied cognition for transforming learning. *International Journal of School & Educational Psychology, 7*(4), 274–288. https://doi.org/10.1080/21683603.2018.1443856

Gadamer, H. G. (1979). *Truth and method* (2nd ed.). Sheed and Ward.

Gale, T. (2012). Towards a southern theory of student equity in Australian higher education: Enlarging the rationale for expansion. *RISE (Barcelona, Spain), 1*(3), 238–262. https://doi.org/10.4471/rise.2012.14

Gale, T., Mills, C., & Cross, R. (2017). Socially Inclusive Teaching : Belief, Design, Action as Pedagogic Work. *Journal of Teacher Education, 68*(3), 345–356. https://doi.org/10.1177/0022487116685754

Garcia-Melgar, A., Hyett, N., Bagley, K., McKinstry, C., Spong, J., & Iacono, T. (2022). Collaborative team approaches to supporting inclusion of children with disability in mainstream schools: A co-design study. *Research in Developmental Disabilities, 126*, 104233–104233. https://doi.org/10.1016/j.ridd.2022.104233

Gay, G. (2013). Teaching To and Through Cultural Diversity. *Curriculum Inquiry, 43*(1), 48–70. https://doi.org/10.1111/curi.12002

Gay, G. (2018). *Culturally responsive teaching : theory, research, and practice* (Third edition.). Teachers College Press.

George, G., McGahan, A. M., & Prabhu, J. (2012). Innovation for Inclusive Growth: Towards a Theoretical Framework and a Research Agenda. *Journal of Management Studies, 49*(4), 661–683. https://doi.org/10.1111/j.1467-6486.2012.01048.x

Getzel, E. E., & Thoma, C. A. (2008). Experiences of College Students With Disabilities and the Importance of Self-Determination in Higher Education Settings. *Career Development for Exceptional Individuals, 31*(2), 77–84. https://doi.org/10.1177/0885728808317658

Ghaziani, R. (2021). Primary school design: co-creation with children. *ArchNet-IJAR, 15*(2), 285 – 299. https://doi.org/10.1108/ARCH-07-2020-0132

Ghesquière, P., Maes, B., & Vandenberghe, R. (2004). The usefulness of qualitative case studies in research on special needs education. *International Journal of Disability, Development, and Education, 51*(2), 171–184. https://doi.org/10.1080/10349120410001687382

Giddens, A. (1984). *The constitution of society: outline of the theory of structuration*. University of California Press.

Gill, S., & Pawluk, D. T. V. (2022). Design of a "Cobot Tactile Display" for Accessing Virtual Diagrams by Blind and Visually Impaired Users. *Sensors (Basel, Switzerland), 22*(12), 4468-. https://doi.org/10.3390/s22124468

Goodyear, P. (2015). Teaching as design. *Herdsa review of higher education, 2*(2), 27-50.

Goodyear, P. (2020). Design and co-configuration for hybrid learning : Theorising the practices of learning space design. *British Journal of Educational Technology, 51*(4), 1045–1060. https://doi.org/10.1111/bjet.12925

Goodyear, P. (2022). Realising the Good University: Social Innovation, Care, Design Justice and Educational Infrastructure. *Postdigital Science and Education, 4*(1), 33–56. https://doi.org/10.1007/s42438-021-00253-5

Goodyear, P., & Carvalho, L. (2014). Introduction: Networked learning and learning networks. In *The Architecture of Productive Learning Networks* (pp. 3–22). https://doi.org/10.4324/9780203591093

Goodyear, P., Carvalho, L., & Yeoman, P. (2021). Activity-Centred Analysis and Design (ACAD): Core purposes, distinctive qualities and current developments. *Educational Technology Research and Development, 69*(2), 445–464. https://doi.org/10.1007/s11423-020-09926-7

Gorlewicz, J. L., Tennison, J. L., Uesbeck, P. M., Richard, M. E., Palani, H. P., Stefik, A., Smith, D. W., & Giudice, N. A. (2020). Design Guidelines and Recommendations for Multimodal, Touchscreen-based Graphics. *ACM Transactions on Accessible Computing, 13*(3), 1–30. https://doi.org/10.1145/3403933

Gray, D. E. (David E. (2014). *Doing research in the real world* (3rd ed.). SAGE.

GREENHALGH, T., JACKSON, C., SHAW, S., & JANAMIAN, T. (2016). Achieving Research Impact Through Co-creation in Community-Based Health Services: Literature Review and Case Study. *The Milbank Quarterly, 94*(2), 392–429. https://doi.org/10.1111/1468-0009.12197

Greeno, J. G., Collins, A. M., & Resnick, L. B. (1996). Cognition and learning. In *Handbook of educational psychology* (pp. 15-46). New York: Macmillan.

Griffin-Shirley, N., Koenig, A. K., Layton, C. A., Davidson, R. C., Siew, L. K., Edmonds, A. R., & Robinson, M. C. (2004). A Survey of Teachers of Students with Visual Impairments: Responsibilities, Satisfactions, and Needs. *RE:View (Washington, D.C.), 36*(1), 7–20. https://doi.org/10.3200/REVU.36.1.7-20

Griffith, A. I. (1998). Insider / Outsider: Epistemological Privilege and Mothering Work. *Human Studies, 21*(4), 361–376. https://doi.org/10.1023/A:1005421211078

Griful-Freixenet, J., Struyven, K., Verstichele, M., & Andries, C. (2017). Higher education students with disabilities speaking out: perceived barriers and opportunities of the Universal Design for Learning framework. *Disability & Society, 32*(10), 1627–1649. https://doi.org/10.1080/09687599.2017.1365695

Grigg, J. (2020). Materials and tools as catalysts of invention in graphic design ideation. *Design Studies, 70*, 100960-. https://doi.org/10.1016/j.destud.2020.100960

Gual, J., Puyuelo, M., & Lloveras, J. (2014). Three-dimensional tactile symbols produced by 3D Printing: Improving the process of memorizing a tactile map key. *The British Journal of Visual Impairment, 32*(3), 263–278. https://doi.org/10.1177/0264619614540291

Gual, J., Puyuelo, M., & Lloveras, J. (2015). The effect of volumetric (3D) tactile symbols within inclusive tactile maps. *Applied Ergonomics, 48*, 1–10. https://doi.org/10.1016/j.apergo.2014.10.018

Guba, E. & Lincoln, Y. (1994) Competing paradigms in qualitative research. In: Denzin, N. & Lincoln, Y. (eds.) *Handbook of qualitative research*. Sage Publications, pp. 163–194.

Guba, E. G. (1990). *The Paradigm dialog*. SAGE Publications.

Guneysu, A., Reis, H. I. S., Kuoppamäki, S., & Sylla, C. M. (2024). Enhancing Autism Therapy through Smart Tangible-Based Digital Storytelling: Co-Design of Activities and Feasibility Study. *Proceedings of ACM Interaction Design and Children Conference: Inclusive Happiness, IDC 2024*, 665–669. https://doi.org/10.1145/3628516.3659371

Gupta, A., Fulfagar, L., Upadhyay, P., Poovaiah, R., Chakrabarti, A., Kant, V., Bokil, P., Chakrabarti, A., Kant, V., Poovaiah, R., & Bokil, P. (2021). Co-designing with Visually Impaired Children. In *Design for Tomorrow--Volume 2* (Vol. 222, pp. 429–439). Springer. https://doi.org/10.1007/978-981-16-0119-4_35

Gupta, R., Rao, P. V. M., Balakrishnan, M., & Mannheimer, S. (2019). Evaluating the Use of Variable Height in Tactile Graphics. *2019 IEEE World Haptics Conference* (WHC), 121–126. https://doi.org/10.1109/WHC.2019.8816083

Hakkarainen, K., Paavola, S., Kangas, K., Seitamaa-Hakkarainen, P., O'Donnell, A. M., Hmelo-Silver, C. E., Chinn, C. A., & Chan, C. K. K. (2013). Sociocultural Perspectives on Collaborative Learning: Toward Collaborative Knowledge Creation. In *The International Handbook of Collaborative Learning* (1st ed., pp. 57–73). Routledge. https://doi.org/10.4324/9780203837290-5

Halskov, K., & Hansen, N. B. (2015). The diversity of participatory design research practice at participatory designC 2002–2012. *International Journal of Human-Computer Studies, 74*, 81–92. https://doi.org/10.1016/j.ijhcs.2014.09.003

Hancock, C. L., & Miller, A. L. (2018). Using cultural historical activity theory to uncover praxis for inclusive education. *International Journal of Inclusive Education, 22*(9), 937–953. https://doi.org/10.1080/13603116.2017.1412517

Hatano, G., & Wertsch, J. V. (2001). Sociocultural Approaches to Cognitive Development: The Constitutions of Culture in Mind. *Human Development, 44*(2/3), 77–83. https://doi.org/10.1159/000057047

Hatch, M. J. (1997). Irony and the Social Construction of Contradiction in the Humor of a Management Team. *Organization Science (Providence, R.I.), 8*(3), 275–288. https://doi.org/10.1287/orsc.8.3.275

Heath, C., Hindmarsh, J., & Luff, P. (2010). *Video in qualitative research : analysing social interaction in everyday life*. SAGE.

Hemmert, F., Hamann, S., Löwe, M., Zeipelt, J., & Joost, G. (2010). Co-designing with children: a comparison of embodied and disembodied sketching techniques in the design of child age communication devices. *Proceedings of IDC2010: The 9th International Conference on Interaction Design and Children*, 202–205. https://doi.org/10.1145/1810543.1810571

Henkel, M. (2005). Academic Identity and Autonomy in a Changing Policy Environment. *Higher Education, 49*(1/2), 155–176. https://doi.org/10.1007/s10734-004-2919-1

Herbel-Eisenmann, B. A., Lloyd, G. M., & Remillard, J. (2009). *Mathematics teachers at work : connecting curriculum materials and classroom instruction*. Routledge.

Hijab, M. H. F., Banire, B., Neves, J., Qaraqe, M., Othman, A., & Al-Thani, D. (2024). Co-design of Technology Involving Autistic Children: A Systematic Literature Review. *International Journal of Human-Computer Interaction, 40*(22), 7498–7516. https://doi.org/10.1080/10447318.2023.2266248

Hirsch, E. D. (2016). *Why knowledge matters : rescuing our children from failed educational theories*. Harvard Education Press.

Hisherik, M., Gindi, S., Awida, N., & Saada, N. (2025). Developing intercultural competence in a training program for boundary-crossing Jewish and Palestinian pre-service teachers. *Teaching and Teacher Education, 159*, 104996. https://doi.org/10.1016/j.tate.2025.104996

Hodder, I. (2012). *Entangled : an archaeology of the relationships between humans and things*. Wiley.

Hodder, I. (2014). The Entanglements of Humans and Things: A Long-Term View. New *Literary History, 45*(1), 19–36. https://doi.org/10.1353/nlh.2014.0005

Hodson, E., Svanda, A., & Dadashi, N. (2023). Whom do we include and when? participatory design with vulnerable groups. *CoDesign, 19*(4), 269-286. https://doi.org/10.1080/15710882.2022.2160464

Hofstede, G. (2011). Dimensionalizing cultures: The Hofstede model in context. *Online readings in psychology and culture, 2*(1), 8.

Hoover, E., & Harder, M. K. (2015). What lies beneath the surface? The hidden complexities of organizational change for sustainability in higher education. *Journal of Cleaner Production, 106*, 175–188. https://doi.org/10.1016/j.jclepro.2014.01.081

Hornby, G., & Lafaele, R. (2011). Barriers to parental involvement in education: an explanatory model. *Educational Review (Birmingham), 63*(1), 37–52. https://doi.org/10.1080/00131911.2010.488049

Huang, R., Yang, W., & Li, H. (2019). On the road to participatory pedagogy: A mixed-methods study of pedagogical interaction in Chinese kindergartens. *Teaching and Teacher Education, 85*, 81–91. https://doi.org/10.1016/j.tate.2019.06.009

Hughes, B., & Jansson, G. (1994). Texture perception via active touch. *Human Movement Science, 13*(3), 301–333. https://doi.org/10.1016/0167-9457(94)90044-2

Hurley, E., Trischler, J., & Dietrich, T. (2018). Exploring the application of co-design to transformative service research. *The Journal of Services Marketing, 32*(6), 715–727. https://doi.org/10.1108/JSM-09-2017-0321

Hutchins, E. (1995). *Cognition in the wild*. MIT Press.

Hutchins, E. (2000). The cognitive consequences of patterns of information flow. *Intellectica, 1*, 53–74.

Hutchins, E., Resnick, L. B., Teasley, S. D., & Levine, J. M. (1991). The social organization of distributed cognition. In *Perspectives on socially shared cognition* (pp. 283–307). American Psychological Association. https://doi.org/10.1037/10096-012

Hyysalo, V., & Hyysalo, S. (2018). The Mundane and Strategic Work in Collaborative Design. *Design Issues, 34*(3), 42–58. https://doi.org/10.1162/desi_a_00496

Ingold, T. (2007). Materials against materiality. *Archaeological Dialogues, 14*(1), 1–16. https://doi.org/10.1017/S1380203807002127

Ingold, T. (2011). *Being alive: essays on movement, knowledge and description*. Routledge.

Ingold, T. (2012). Toward an Ecology of Materials. *Annual Review of Anthropology, 41*(1), 427–442. https://doi.org/10.1146/annurev-anthro-081309-145920

Ingold, T. (2013). *Making : anthropology, archaeology, art and architecture*. Routledge.

Iranzo Bartolomé, J., Cho, J. D., Cavazos Quero, L., Jo, S., & Cho, G. (2020). Thermal Interaction for Improving Tactile Artwork Depth and Color-Depth Appreciation for Visually Impaired People. *Electronics (Basel), 9*(11), 1939-. https://doi.org/10.3390/electronics9111939

Irvine, J. J. (2003). *Educating teachers for diversity: Seeing with a cultural eye*. Teachers College Press.

Isling Poromaa, P. (2017). The significance of materiality in shaping institutional habitus: exploring dynamics preceding school effects. *British Journal of Sociology of Education, 38*(3), 384–402. https://doi.org/10.1080/01425692.2015.1093406

Iversen, O. S., Smith, R. C., & Dindler, C. (2017). Child as protagonist: Expanding the role of children in participatory design. In *Proceedings of the 2017 conference on interaction design and children* (pp. 27-37). https://doi.org/10.1145/3078072.3079725

Jaber, L. Z., & Hammer, D. (2016). Learning to Feel Like a Scientist. *Science Education (Salem, Mass.), 100*(2), 189–220. https://doi.org/10.1002/sce.21202

Jacobson, R. D. (1998). Cognitive Mapping Without Sight: four preliminary studies of spatial learning. *Journal of Environmental Psychology, 18*(3), 289–305. https://doi.org/10.1006/jevp.1998.0098

Jagtap, S. (2022). Co-design with marginalised people: designers' perceptions of barriers and enablers. *CoDesign, 18*(3), 279–302. https://doi.org/10.1080/15710882.2021.1883065

Jellison, J., Brown, L., & Draper, E. (2015). Peer-Assisted Learning and Interactions in Inclusive Music Classrooms: Benefits, Research, and Applications. *General Music Today, 28*(3), 18–22. https://doi.org/10.1177/1048371314565456

Jenlink, P. M. (2001). Activity theory and the design of educational systems: examining the mediational importance of conversation. *Systems Research and Behavioral Science, 18*(4), 345–359. https://doi.org/10.1002/sres.429

Johansson-Sköldberg, U., Woodilla, J., & Çetinkaya, M. (2013). Design Thinking: Past, Present and Possible Futures. *Creativity and Innovation Management, 22*(2), 121–146. https://doi.org/10.1111/caim.12023

Johnson, K. O., & Hsiao, S. S. (1992). Neural mechanisms of tactual form and texture perception. *Annual Review of Neuroscience, 15*(1), 227–250. https://doi.org/10.1146/annurev.ne.15.030192.001303

Johnson, M. P., Ballie, J., Thorup, T., Brooks, E., & Brooks, E. (2017). CO/DEsign: building a shared dialogue around analysis within co-design. *The Design Journal, 20*(1), S4241–S4252. https://doi.org/10.1080/14606925.2017.1352922

Jones, P., & Kijima, K. (2018). Contexts of Co-creation: Designing with System Stakeholders. In *Systemic Design* (pp. 3–52). Springer Japan. https://doi.org/10.1007/978-4-431-55639-8_1

Jordan, A., Glenn, C., & McGhie-Richmond, D. (2010). The Supporting Effective Teaching (SET) project: The relationship of inclusive teaching practices to teachers' beliefs about disability and ability, and about their roles as teachers. *Teaching and Teacher Education, 26*(2), 259–266. https://doi.org/10.1016/j.tate.2009.03.005

Jordan, B., & Henderson, A. (1995). Interaction Analysis: Foundations and Practice. *The Journal of the Learning Sciences, 4*(1), 39–103. https://doi.org/10.1207/s15327809jls0401_2

Kagawa, S., & Moro, Y. (2009). Spinozic Reconsiderations of the Concept of Activity: Politico-Affective Process and Discursive Practice in Transitive Learning. In *Learning and Expanding with Activity Theory* (pp. 176–194). Cambridge University Press. https://doi.org/10.1017/CBO9780511809989.012

Kali, Y., Eylon, B.-S., McKenney, S., Kidron, A., Polly, D., Doyle, R., Lockee, B. B., Spector, J. M., & Childress, M. D. (2023). Design-Centric Research-Practice Partnerships: Three Key Lenses for Building Productive Bridges Between Theory and Practice. In *Learning, Design, and Technology* (pp. 481–511). Springer International Publishing. https://doi.org/10.1007/978-3-319-17461-7_122

Kant, I., & Walford, D. (1992). *Theoretical Philosophy, 1755–1770*. Cambridge University Press. https://doi.org/10.1017/CBO9780511840180

Kaplan, R. B. (2002). *The Oxford handbook of applied linguistics*. Oxford University Press.

Karpov, Y. V., & Haywood, H. C. (1998). Two ways to elaborate Vygotsky's concept of mediation. *The American Psychologist, 53*(1), 27–36. https://doi.org/10.1037/0003-066X.53.1.27

Ke, L., Friedrichsen, P., Rawson, R., & Sadler, T. D. (2023). Teacher learning through collaborative curriculum design in the midst of a pandemic: A cultural historical activity theory investigation. *Teaching and Teacher Education, 122*, 103957-. https://doi.org/10.1016/j.tate.2022.103957

Kelly, N., Wright, N., Dawes, L., Kerr, J., & Robertson, A. (2019). Co-design for Curriculum Planning : A Model for Professional Development for High School Teachers. *The Australian Journal of Teacher Education, 44*(7), 84–107. https://doi.org/10.14221/ajte.2019v44n7.6

Kenny, W. R., & Grotelueschen, A. D. (1984). Making the case for case study. *J. Curriculum Studies, 16*(1), 37-51.

Kiernan, L., Ledwith, A., & Lynch, R. (2020). Comparing the dialogue of experts and novices in interdisciplinary teams to inform design education. *International Journal of Technology and Design Education, 30*(1), 187–206. https://doi.org/10.1007/s10798-019-09495-8

Kim, B. & Reeves, T. C. (2007). Reframing research on learning with technology: in search of the meaning of cognitive tools. *Instructional Science, 35*(3), 207–256. https://doi.org/10.1007/s11251-006-9005-2

Kim, Y., & Corn, A. L. (1998). The Effects of Teachers' Characteristics on Placement Recommendations for Students with Visual Impairments. *Journal of Visual Impairment & Blindness, 92*(7), 491–502. https://doi.org/10.1177/0145482X9809200709

Kimpel, K., Gengnagel, C., Stark, R., & Nagy, E. (2015). Design Prototyping for Research Planning and Technological Development. In *Rethink! Prototyping* (pp. 23–35). Springer International Publishing AG. https://doi.org/10.1007/978-3-319-24439-6_3

Kittscha, J., Wilson, V., Fairbrother, G., & Bliokas, V. (2024). How the expert nursing role was used to facilitate the co-design of a patient interview study. *Nurse Researcher, 32*(2), 14–21. https://doi.org/10.7748/nr.2024.e1918

Kitzinger, J. (1995). Qualitative Research: Introducing focus groups. *BMJ, 311*(7000), 299–302. https://doi.org/10.1136/bmj.311.7000.299

Kleinsmann, M., & Valkenburg, R. (2008). Barriers and enablers for creating shared understanding in co-design projects. *Design Studies, 29*(4), 369–386. https://doi.org/10.1016/j.destud.2008.03.003

Kliskey, A. A., Williams, P., Trammell, E. J., Cronan, D., Griffith, D., Alessa, L., Lammers, R., Haro-Martí, M. E. de, & Oxarango-Ingram, J. (2023). Building trust, building futures: Knowledge co-production as relationship, design, and process in transdisciplinary science. *Frontiers in Environmental Science, 11*. https://doi.org/10.3389/fenvs.2023.1007105

Knight, T., & Stiny, G. (2015). Making grammars: From computing with shapes to computing with things. *Design Studies, 41*, 8–28. https://doi.org/10.1016/j.destud.2015.08.006

Kolb, A. Y., & Kolb, D. A. (2005). Learning styles and learning spaces: Enhancing experiential learning in higher education. *Academy of Management Learning & Education, 4*(2), 193–212. https://doi.org/10.5465/AMLE.2005.17268566

Konings, K. D., Brand-Gruwel, S., & Van Merrienboer, J. J. G. (2005). Towards more powerful learning environments through combining the perspectives of designers, teachers, and students. *British Journal of Educational Psychology, 75*(4), 645–660. https://doi.org/10.1348/000709905X43616

Kucirkova, N., & Rodriguez-Leon, L. (2023). Multisensory Reading in Early Childhood: Systematic Review with Theoretical Guidance for Human Development Studies. *Human Development, 67*(4), 193–210. https://doi.org/10.1159/000531633

Kuhn, T. S. (1962). *The structure of scientific revolutions*. University of Chicago Press.

Kulviwat, S., C. Bruner II, G., & P. Neelankavil, J. (2014). Self-efficacy as an antecedent of cognition and affect in technology acceptance. *The Journal of Consumer Marketing, 31*(3), 190–199. https://doi.org/10.1108/JCM-10-2013-0727

Kvale, S. (1996). *Interviews : an introduction to qualitative research interviewing*. Sage Publications.

Kvale, S., & Brinkmann, S. (2015). *InterViews : learning the craft of qualitative research interviewing* (Third edition.). Sage Publications.

Kyza, E. A., & Agesilaou, A. (2022). Investigating the Processes of Teacher and Researcher Empowerment and Learning in Co-design Settings. *Cognition and Instruction, 40*(1), 100–125. https://doi.org/10.1080/07370008.2021.2010213

Könings, K. D., Seidel, T., & van Merriënboer, J. J. G. (2014). Participatory design of learning environments: integrating perspectives of students, teachers, and designers. *Instructional Science, 42*(1), 1–9. https://doi.org/10.1007/s11251-013-9305-2

Ladner, R. E., Ivory, M. Y., Rao, R., Burgstahler, S., Comden, D., Hahn, S., Renzelmann, M., Krisnandi, S., Ramasamy, M., Slabosky, B., Martin, A., Lacenski, A., Olsen, S., & Groce, D. (2005). Automating tactile graphics translation. *ASSETS 2005 - The Seventh International ACM SIGACCESS Conference on Computers and Accessibility*, 150–157. https://doi.org/10.1145/1090785.1090814

Lahti, H., & Seitamaa-Hakkarainen, P. (2005). Towards participatory design in craft and design education. *CoDesign, 1*(2), 103–117. https://doi.org/10.1080/15710880500137496

Lapadat, J. C., & Lindsay, A. C. (1999). Transcription in Research and Practice: From Standardization of Technique to Interpretive Positionings. *Qualitative Inquiry, 5*(1), 64–86. https://doi.org/10.1177/107780049900500104

Large, A., Bowler, L., Beheshti, J., & Nesset, V. (2007). Creating Web Portals with Children as Designers: Bonded Design and the Zone of Proximal Development. *McGill Journal of Education, 42*(1), 61-.

Large, A., Nesset, V., Beheshti, J., & Bowler, L. (2006). “Bonded design”: A novel approach to intergenerational information technology design. *Library & Information Science Research, 28*(1), 64–82. https://doi.org/10.1016/j.lisr.2005.11.014

Larsson, A. S., & Lamb, M. E. (2009). Making the most of information-gathering interviews with children. *Infant and Child Development, 18*(1), 1–16. https://doi.org/10.1002/icd.573

Lashitew, A. A., Bals, L., & van Tulder, R. (2020). Inclusive Business at the Base of the Pyramid: The Role of Embeddedness for Enabling Social Innovations. *Journal of Business Ethics, 162*(2), 421–448. https://doi.org/10.1007/s10551-018-3995-y

Latour, B. (2004). How to Talk About the Body? the Normative Dimension of Science Studies. *Body & Society, 10*(2–3), 205–229. https://doi.org/10.1177/1357034X04042943

Latour, B. (2018). *Down to earth : politics in the new climatic regime* (C. Porter, Tran.; English edition.). Polity Press.

Lave, J. (1988). *Cognition in practice : mind, mathematics, and culture in everyday life*. Cambridge University Press.

Lave, J., & Wenger, E. (1991). *Situated learning : legitimate peripheral participation*.

Cambridge University Press.

Lawrence, M. M., & Lobben, A. K. (2011). The Design of Tactile Thematic Symbols. Journal of Visual Impairment & Blindness, 105(10), 681–691. https://doi.org/10.1177/0145482X1110501014

Lee, C.-L. (2019). An evaluation of tactile symbols in public environment for the visually impaired. *Applied Ergonomics, 75*, 193–200. https://doi.org/10.1016/j.apergo.2018.10.003

Lee, J., Ahn, J., Kim, J., & Kho, J. (2019a). Co-Design Education Based on the Changing Designer's Role and Changing Creativity. *The International Journal of Art & Design Education, 38*(2), 430–444. https://doi.org/10.1111/jade.12204

Lee, J., Cho, H., Chung, J., & Lee, Y. (2019b). Enabling people to lower barriers with a codesign prototyping approach: sex education for upper-elementary students at home. *The Design Journal, 22*(S1), 539–551. https://doi.org/10.1080/14606925.2019.1595437

Lee, Y. (2008). Design participation tactics: the challenges and new roles for designers in the co-design process. *CoDesign, 4*(1), 31–50. https://doi.org/10.1080/15710880701875613

Lefstein, A., Louie, N., Segal, A., & Becher, A. (2020). Taking stock of research on teacher collaborative discourse: Theory and method in a nascent field. *Teaching and Teacher Education, 88*, 102954-. https://doi.org/10.1016/j.tate.2019.102954

Lehtinen, A., Kostiainen, E., & Näykki, P. (2025). Crossing boundaries–pre-service teachers' situated and imagined views of socioemotional competence and dialogicality. Learning, *Culture and Social Interaction, 50*, 100880-. https://doi.org/10.1016/j.lcsi.2024.100880

Létourneau, A., Deslandes Martineau, M., Charland, P., Karran, J. A., Boasen, J., & Léger, P. M. (2025). A systematic review of AI-driven intelligent tutoring systems (ITS) in K-12 education. *NPJ Science of Learning, 10*(1), Article 29. https://doi.org/10.1038/s41539-025-00320-7

Leont'ev, A. N. (1978). *Activity, consciousness, and personality*. Prentice-Hall.

Leont'ev, A. N. (1981). *Problems of the development of the mind*. Progress.

Li, H., Lin, J., Wu, H., Li, Z., & Han, M. (2021). "How do I survive exclusion?" Voices of students with disabilities at China's top universities. *Children and Youth Services Review, 120*, 105738-. https://doi.org/10.1016/j.childyouth.2020.105738

Liegl, M., Boden, A., Büscher, M., Oliphant, R., & Kerasidou, X. (2016). Designing for ethical innovation: A case study on ELSI co-design in emergency. *International Journal* *of Human-Computer Studies, 95*, 80–95. https://doi.org/10.1016/j.ijhcs.2016.04.003

Lin, C.-Y., Lin, C.-C., Chen, C.-J., Huang, M.-R., Zhang, Y., & Zhang, Y. (2012). Real-Time Interactive Teaching Materials for Students with Disabilities. In *Future Communication, Computing, Control and Management* (Vol. 142, Number 2, pp. 369–375). Springer Berlin / Heidelberg. https://doi.org/10.1007/978-3-642-27314-8_50

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Sage Publications.

Lipka, O., Forkosh Baruch, A., & Meer, Y. (2019). Academic support model for post-secondary school students with learning disabilities: student and instructor perceptions. *International Journal of Inclusive Education, 23*(2), 142–157. https://doi.org/10.1080/13603116.2018.1427151

Liu, Y., & Xu, Y. (2011). Inclusion or exclusion?: A narrative inquiry of a language teacher's identity experience in the 'new work order' of competing pedagogies. *Teaching and Teacher Education, 27*(3), 589–597. https://doi.org/10.1016/j.tate.2010.10.013

Liu, M. (2023). An overview on the impact of the exam-oriented education in China. *SHS Web of Conferences, 180*, 2036. https://doi.org/10.1051/shsconf/202318002036

Lloyd, G. M. (1999). Two Teachers' Conceptions of a Reform-Oriented Curriculum: Implications for Mathematics Teacher Development. *Journal of Mathematics Teacher Education, 2*(3), 227-252.

Lloyd-Esenkaya, T., Lloyd-Esenkaya, V., O'Neill, E., & Proulx, M. J. (2020). Multisensory inclusive design with sensory substitution. *Cognitive Research: Principles and Implications, 5*(1), 37–37. https://doi.org/10.1186/s41235-020-00240-7

Lowy, R., Magiawala, K., Mittal, S., Hall, K., Roberts, J., & Kim, J. G. (2024). Research-Education Partnerships: A Co-Design Classroom for College Students with Intellectual and Developmental Disabilities. *Proceedings of the ACM on Human-Computer Interaction, 8*(CSCW2), 1–26. https://doi.org/10.1145/3687050

Lozanovska, M., & Xu, L. (2013). Children and university architecture students working together: a pedagogical model of children's participation in architectural design. *CoDesign, 9*(4), 209–229. https://doi.org/10.1080/15710882.2012.693187

Maatuk, A. M., Elberkawi, E. K., Aljawarneh, S., Rashaideh, H., & Alharbi, H. (2022). The COVID-19 pandemic and E-learning: challenges and opportunities from the perspective of students and instructors. *Journal of Computing in Higher Education, 34*(1), 21–38. https://doi.org/10.1007/s12528-021-09274-2

Mackenzie, N., & Knipe, S. (2006). Research dilemmas : paradigms, methods and methodology. *Issues in Educational Research, 16*(2), 193–205.

Magkafa, D., Newbutt, N., Palmer, M., Jain, L. C., Brahman, S., Nakajima, A., Kapralos, B., Tyerman, J., Brooks, A. L., Brahman, S., Kapralos, B., Brooks, A. L., Nakajima, A., Tyerman, J., & Jain, L. C. (2021). Implementing Co-Design Practices for the Development of a Museum Interface for Autistic Children. In *Recent Advances in Technologies for Inclusive Well-Being* (Vol. 196, pp. 421 – 443). Springer International Publishing AG. https://doi.org/10.1007/978-3-030-59608-8_22

Magnusson, C., Hedvall, P.-O., Caltenco, H., Velazquez, R., Pissaloux, E., Velazquez, R., & Pissaloux, E. (2017). Co-designing together with Persons with Visual Impairments. In *Mobility of Visually Impaired People* (pp. 411–434). Springer International Publishing AG. https://doi.org/10.1007/978-3-319-54446-5_14

Maher, A. J., Williams, D., & Sparkes, A. C. (2020). Teaching non-normative bodies: simulating visual impairments as embodied pedagogy in action. *Sport, Education and Society, 25*(5), 530–542. https://doi.org/10.1080/13573322.2019.1617127

Manouchehri, A., & Goodman, T. (2000). Implementing Mathematics Reform: The Challenge within. *Educational Studies in Mathematics, 42*(1), 1–34. https://doi.org/10.1023/A:1004011522216

Manzini, E. (2015). *Design, when everybody designs : an introduction to design for social innovation*. The MIT Press.

Manzini, E. (2016). Design Culture and Dialogic Design. *Design Issues, 32*(1), 52–59. https://doi.org/10.1162/DESI_a_00364

Manzini, E., & Cau, P. (1989). *The material of invention* (1st MIT Press ed.). MIT.

Markham, C., van Laar, D., Gibbard, D., & Dean, T. (2009). Children with speech, language and communication needs: their perceptions of their quality of life. *International Journal of Language & Communication Disorders, 44*(5), 748–768. https://doi.org/10.1080/13682820802359892

Martens, S. E., Meeuwissen, S. N. E., Dolmans, D. H. J. M., Bovill, C., & Könings, K. D. (2019). Student participation in the design of learning and teaching: Disentangling the terminology and approaches. *Medical Teacher, 41*(10), 1203–1205. https://doi.org/10.1080/0142159X.2019.1615610

Martin, A. (2000). The Design and Evolution of a Simulation/Game for Teaching Information Systems Development. *Simulation & Gaming, 31*(4), 445–463. https://doi.org/10.1177/104687810003100401

Masiello, I., Mohseni, Z. (Artemis), Palma, F., Nordmark, S., Augustsson, H., & Rundquist, R. (2024). A Current Overview of the Use of Learning Analytics Dashboards. *Education Sciences, 14*(1), Article 82. https://doi.org/10.3390/educsci14010082

Matthews, B., Stienstra, M., & Djajadiningrat, T. (2008). Emergent Interaction: Creating Spaces for Play. *Design Issues, 24*(3), 58–71. https://doi.org/10.1162/desi.2008.24.3.58

McCallum, D., Ahmed, K., Jehoel, S., Dinar, S., & Sheldon, D. (2005). The design and manufacture of tactile maps using an inkjet process. *Journal of Engineering Design, 16*(6), 525–544. https://doi.org/10.1080/09544820500273946

McCormick, R., & Paechter, C. (1999). *Learning & Knowledge* (Vol. 3). Sage.

McKenney, S., Kali, Y., Markauskaite, L., & Voogt, J. (2015). Teacher design knowledge for technology enhanced learning: an ecological framework for investigating assets and needs. *Instructional Science, 43*(2), 181–202. https://doi.org/10.1007/s11251-014-9337-2

McKeon, R. (1957). Communication, Truth, and Society. *Ethics, 67*(2), 89–99. https://doi.org/10.1086/291096

Medlock, M. C., Wixon, D., Terrano, M., Romero, R., & Fulton, B. (2002). Using the RITE method to improve products: A definition and a case study. *Usability Professionals Association, 51*(1).

Melfi, G., Müller, K., Schwarz, T., Jaworek, G., & Stiefelhagen, R. (2020). Understanding what you feel: A Mobile Audio-Tactile System for Graphics Used at Schools with Students with Visual Impairment. *Conference on Human Factors in Computing Systems - Proceedings*, 381–381. https://doi.org/10.1145/3313831.3376508

Merleau-Ponty, M. (2004). *The world of perception*. Routledge. https://doi.org/10.4324/9780203491829

Merriam, S. B. (1998). *Qualitative research and case study applications in education* (2nd ed.). Jossey-Bass Publishers.

Merriam, S. B., & Tisdell, E. J. (2015). *Qualitative research: A guide to design and implementation* (4th ed.). Wiley.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis : an expanded sourcebook* (2nd ed.). Sage Publications.

Mohanty, C. T. (1988). Under Western Eyes: Feminist Scholarship and Colonial Discourses. *Feminist Review, 30*(1), 61–88. https://doi.org/10.1057/fr.1988.42

Mojtar-Mendieta, L., Rascón-Gómez, T., & Calderón-Almendros, I. (2025). Students as subjects. Resistance, youth agency, and inclusive education through participatory action research. *International Journal of Qualitative Studies in Education, 38*(3), 338–355. https://doi.org/10.1080/09518398.2025.2454281

Moll, L. C., Amanti, C., Neff, D., & Gonzalez, N. (1992). Funds of knowledge for teaching: Using a qualitative approach to connect homes and classrooms. *Theory into Practice, 31*(2), 132–141. https://doi.org/10.1080/00405849209543534

Moll, S., Wyndham-West, M., Mulvale, G., Park, S., Buettgen, A., Phoenix, M., Fleisig, R., & Bruce, E. (2020). Are you really doing 'codesign'? Critical reflections when working with vulnerable populations. *BMJ Open, 10*(11), e038339 – e038339. https://doi.org/10.1136/bmjopen-2020-038339

Moonen, J. (1999). The design and prototyping of digital learning material: Some new perspectives. *Design approaches and tools in education and training*, 95-111.

Mor, Y., Craft, B., & Hernández Leo, D. (2013). The art and science of learning design. *Research in Learning Technology. 2013; 21*: 1-8.

Mukhiddinov, M., & Kim, S. Y. (2021). A systematic literature review on the automatic creation of tactile graphics for the blind and visually impaired. Processes, 9(10), 1726-. https://doi.org/10.3390/pr9101726

Murphy, E., & Rodriguez-Manzanares, M. A. (2008). Using activity theory and its principle of contradictions to guide research in educational technology. *Australasian Journal of Educational Technology, 24*(4), 442–457. https://doi.org/10.14742/ajet.1203

Murray, C., Wren, C. T., & Keys, C. (2008). University Faculty Perceptions of Students with Learning Disabilities: Correlates and Group Differences. *Learning Disability Quarterly, 31*(3), 95–113. https://doi.org/10.2307/25474642

Mwakyeja, B. M. (2013). Teaching students with visual impairments in inclusive classrooms. *A case study of one Secondary School in Tanzania. University of Oslo. Retrieved December, 5*, 2017.

Mwanza, D., & Engeström, Y. (2005). Managing content in e-learning environments. British Journal of Educational Technology, 36(3), 453–463. https://doi.org/10.1111/j.1467-8535.2005.00479.x

Mäkelä, T., Helfenstein, S., Lerkkanen, M.-K., & Poikkeus, A.-M. (2018). Student participation in learning environment improvement: analysis of a co-design project in a Finnish upper secondary school. *Learning Environments Research, 21*(1), 19–41. https://doi.org/10.1007/s10984-017-9242-0

Naraian, S., & Schlessinger, S. (2018). Becoming an inclusive educator: Agentive maneuverings in collaboratively taught classrooms. *Teaching and Teacher Education, 71*, 179–189. https://doi.org/10.1016/j.tate.2017.12.012

Nardi, B. A. (1996). *Context and consciousness : activity theory and human-computer interaction*. MIT Press.

Ng, A. W., & Chan, A. H. (2014). Tactile symbol matching of different shape patterns: Implications for shape coding of control devices. In *Proceedings of the international multiconference of engineers and computer scientists* (Vol. 2).

Nicot, R., Hurteloup, E., Joachim, S., Druelle, C., & Levaillant, J.-M. (2021). Using low-cost 3D-printed models of prenatal ultrasonography for visually-impaired expectant persons. *Patient Education and Counseling, 104*(9), 2146–2151. https://doi.org/10.1016/j.pec.2021.02.033

Noorbergen, T. J., Adam, M. T. P., Teubner, T., & Collins, C. E. (2021). Using co-design in mobile health system development: A qualitative study with experts in co-design and mobile health system development. *JMIR mHealth and uHealth, 9*(11), e27896–e27896. https://doi.org/10.2196/27896

Oliver, M. (2013). Learning technology: Theorising the tools we study. *British Journal of Educational Technology, 44*(1), 31–43. https://doi.org/10.1111/j.1467-8535.2011.01283.x

Osorio-Saez, E. M., Eryilmaz, N., & Sandoval-Hernandez, A. (2021). Parents' Acceptance of Educational Technology: Lessons From Around the World. *Frontiers in Psychology, 12*, 719430–719430. https://doi.org/10.3389/fpsyg.2021.719430

O'Brien, N., Heaven, B., Teal, G., Evans, E. H., Cleland, C., Moffatt, S., Sniehotta, F. F., White, M., Mathers, J. C., & Moynihan, P. (2016). Integrating evidence from systematic reviews, qualitative research, and expert knowledge using co-design techniques to develop a web-based intervention for people in the retirement transition. *Journal of Medical Internet Research, 18*(8), e210–e210. https://doi.org/10.2196/jmir.5790

O'Modhrain, S., Giudice, N. A., Gardner, J. A., & Legge, G. E. (2015). Designing Media for Visually-Impaired Users of Refreshable Touch Displays: Possibilities and Pitfalls. *IEEE Transactions on Haptics, 8*(3), 248–257. https://doi.org/10.1109/TOH.2015.2466231

O'Rourke, J., Kueh, C., Holly, C., Brook, L., & Erickson, C. (2023). Co-designing a communication app to enhance collaborative communication support for secondary students with autism. *Educational Technology Research and Development, 71*(2), 579–604. https://doi.org/10.1007/s11423-022-10170-4

Pagliano, P. J. (2012). *The multisensory handbook : a guide for children and adults with sensory learning disabilities*. Routledge. https://doi.org/10.4324/9780203117385

Panke, S. (2019). Design Thinking in Education: Perspectives, Opportunities and Challenges. *Open Education Studies, 1*(1), 281–306. https://doi.org/10.1515/edu-2019-0022

Panke, S., & Harth, T. (2019). Design thinking for inclusive community design:(How) does it work?. *Journal of Interactive Learning Research, 30*(2), 195-214.

Panotopoulou, A., Zhang, X., Qiu, T., Yang, X.-D., & Whiting, E. (2020). Tactile line drawings for improved shape understanding in blind and visually impaired users. *ACM Transactions on Graphics, 39*(4), 89:1-89:13. https://doi.org/10.1145/3386569.3392388

Paracha, S., Hall, L., Clawson, K., Mitsche, N., & Jamil, F. (2019). Co-design with children: using participatory design for design thinking and social and emotional learning. *Open Education Studies, 1*(1), 267-280.

Park, J., & Hong, S. (2023). Creating tactile graphics in school settings: A survey of training experience, competence, challenges, and future support needs. *British Journal of Visual Impairment, 41*(4), 864-875. https://doi.org/10.1177/02646196221109080.

Parnell, R., Cave, V., & Torrington, J. (2008). School design: opportunities through collaboration. *CoDesign, 4*(4), 211–224. https://doi.org/10.1080/15710880802524904

Peirce, C. S. (1992). *The Essential Peirce, Volume 2: Selected Philosophical Writings* (1893-1913) (Vol. 2). Indiana University Press.

Penin, L., & Bonsiepe, G. (2022). Some Virtues of Design: 2007. In *The Disobedience of Design* (pp. 97–103). Bloomsbury Publishing Plc. https://doi.org/10.5040/9781350162488.0020

Penuel, W. R., Roschelle, J., & Shechtman, N. (2007). Designing formative assessment software with teachers: An analysis of the co-design process. *Research and Practice in Technology Enhanced Learning, 2*(1), 51-74. https://doi.org/10.1142/S1793206807000300

Phutane, M., Wright, J., Castro, B. V., Shi, L., Stern, S. R., Lawson, H. M., & Azenkot, S. (2022). Tactile Materials in Practice: Understanding the Experiences of Teachers of the Visually Impaired. *ACM Transactions on Accessible Computing, 15*(3), 1–34. https://doi.org/10.1145/3508364

Pierri, P. (2018). Participatory Design Practices in Mental Health in the UK: Rebutting the Optimism. *Design Issues, 34*(4), 25–36. https://doi.org/10.1162/desi_a_00509

Poole, A. (2024). The teacher as designer, scientist and technician: positioning private school teachers in China as post-performative teachers. *Educational Review (Birmingham), 76*(7), 1898–1916. https://doi.org/10.1080/00131911.2024.2302414

Postholm, M. B. (2015). Methodologies in Cultural-Historical Activity Theory: The example of school-based development. *Educational Research (Windsor), 57*(1), 43–58. https://doi.org/10.1080/00131881.2014.983723

Prescher, D., Bornschein, J., & Weber, G. (2014). Production of accessible tactile graphics. In *Computers Helping People with Special Needs: 14th International Conference, ICCHP 2014, Paris, France, July 9-11, 2014, Proceedings, Part II 14* (pp. 26-33). Springer International Publishing.

Proudfoot, K. (2023). Inductive/Deductive Hybrid Thematic Analysis in Mixed Methods Research. *Journal of Mixed Methods Research, 17*(3), 308–326. https://doi.org/10.1177/15586898221126816

Punch, K. (2005). *Introduction to social research : quantitative and qualitative approaches* (2nd ed.). SAGE Publications.

Puig de la Bellacasa, M. (2017). *Matters of care : speculative ethics in more than human worlds*. University of Minnesota Press. http://www.jstor.org/stable/10.5749/j.ctt1mmfspt

Perkins School for the Blind. (2025a, Oct 11). *Tactile graphics library*. https://www.perkins.org/resource/tactile-graphics-library/

Perkins School for the Blind. (2025b, Oct 11). *Giant steps: Orientation and mobility*. https://www.perkins.org/giant-steps-orientation-and-mobility/

Pye, D. (1968). *The nature and art of workmanship*. Cambridge University Press.

Qu, X. (2019). *Inclusive education in Chinese primary schools–a critical realist analysis*, Doctoral dissertation, UCL (University College London)).

Race, L., Fleet, C., Miele, J. A., Igoe, T., & Hurst, A. (2019). Designing Tactile Schematics: Improving Electronic Circuit Accessibility. *ASSETS 2019 - 21st International ACM SIGACCESS Conference on Computers and Accessibility*, 581–583. https://doi.org/10.1145/3308561.3354610

Rajapakse, R., Brereton, M., & Sitbon, L. (2021). A respectful design approach to facilitate codesign with people with cognitive or sensory impairments and makers. *CoDesign, 17*(2), 159 – 187. https://doi.org/10.1080/15710882.2019.1612442

Raman, S., & French, T. (2022). Enabling genuine participation in co-design with young people with learning disabilities. *CoDesign, 18*(4), 431 – 447. https://doi.org/10.1080/15710882.2021.1877728

Ramsamy-Iranah, S., Maguire, M., Gardner, J., Rosunee, S., & Kistamah, N. (2016). A comparison of three materials used for tactile symbols to communicate colour to children and young people with visual impairments. *The British Journal of Visual Impairment, 34*(1), 54–71. https://doi.org/10.1177/0264619615610161

Rau, M. A. (2017). Conditions for the Effectiveness of Multiple Visual Representations in Enhancing STEM Learning. *Educational Psychology Review, 29*(4), 717–761. https://doi.org/10.1007/s10648-016-9365-3

Read, J., Fitton, D., & Horton, M. (2021). Capturing and Considering Idea Development in School Pupils' Design Activities. *Interaction Design and Children*, 147 – 152. https://doi.org/10.1145/3459990.3460722

Reich, W. (2000). Diagnostic Interview for Children and Adolescents (DICA). *Journal of the American Academy of Child and Adolescent Psychiatry, 39*(1), 59–66. https://doi.org/10.1097/00004583-200001000-00017

Retna, K. S. (2016). Thinking about "design thinking": a study of teacher experiences. *Asia Pacific Journal of Education, 36*(sup1), 5–19. https://doi.org/10.1080/02188791.2015.1005049

Richards, H. V., Brown, A. F., & Forde, T. B. (2007). Addressing Diversity in Schools: Culturally Responsive Pedagogy. *Teaching Exceptional Children, 39*(3), 64–68. https://doi.org/10.1177/004005990703900310

Richardson, J. C., Ashby, I., Alshammari, A. N., Cheng, Z., Johnson, B. S., Krause, T. S., Lee, D., Randolph, A. E., & Wang, H. (2019). Faculty and instructional designers on building successful collaborative relationships. *Educational Technology Research and Development, 67*(4), 855–880. https://doi.org/10.1007/s11423-018-9636-4

Richardson, J. G. (1986). *Handbook of theory and research for the sociology of education*. Greenwood Press.

Ritzhaupt, A. D., & Kumar, S. (2015). Knowledge and Skills Needed by Instructional Designers in Higher Education. *Performance Improvement Quarterly, 28*(3), 51–69. https://doi.org/10.1002/piq.21196

Robertson, T., & Simonsen, J. (2013). *Routledge international handbook of participatory design*. Routledge. https://doi.org/10.4324/9780203108543

Robinson, D. (2017). Effective inclusive teacher education for special educational needs and disabilities: Some more thoughts on the way forward. *Teaching and Teacher Education, 61*, 164–178. https://doi.org/10.1016/j.tate.2016.09.007

Robson, C. (2002). *Real world research : a resource for social scientists and practitioner-researchers* (2nd ed.). Blackwell Publishers.

Rogoff, B. (1990). *Apprenticeship in thinking : cognitive development in social context*. Oxford University Press.

Rohrer, D., & Pashler, H. (2010). Recent Research on Human Learning Challenges Conventional Instructional Strategies. *Educational Researcher, 39*(5), 406–412. https://doi.org/10.3102/0013189X10374770

Rong, A., & Hansopaheluwakan-Edward, N. (2025). Uncovering facilitators and constraints in co-design with visually impaired children: A sociomateriality perspective. *The Design Journal*, 1-19. https://doi.org/10.1080/14606925.2025.2477929

Rong, A., Hansopaheluwakan-Edward, N., & Li, D. (2025). Visualizing invisible information: a scoping review of present findings, challenges and opportunities on tactile graphics design. *Visual Communication*, *0*(0). https://doi.org/10.1177/14703572241300884

Rosenblum, L. P., & Herzberg, T. S. (2015). Braille and Tactile Graphics: Youths with Visual Impairments Share Their Experiences. *Journal of Visual Impairment & Blindness, 109*(3), 173–184. https://doi.org/10.1177/0145482X1510900302

Rosenblum, L. P., Cheng, L., & Beal, C. R. (2018). Teachers of Students with Visual Impairments Share Experiences and Advice for Supporting Students in Understanding Graphics. *Journal of Visual Impairment & Blindness, 112*(5), 475–487. https://doi.org/10.1177/0145482X1811200505

Rosenblum, L. P., Cheng, L., & Beal, C. R. (2018). Teachers of Students with Visual Impairments Share Experiences and Advice for Supporting Students in Understanding Graphics. *Journal of Visual Impairment & Blindness, 112*(5), 475–487. https://doi.org/10.1177/0145482X1811200505

Roth, W.-M., & Yew-Jin Lee. (2007). “Vygotsky’s Neglected Legacy”: Cultural-Historical Activity Theory. *Review of Educational Research, 77*(2), 186–232. https://doi.org/10.3102/0034654306298273

Royce, W. W. (1987). Managing the development of large software systems: concepts and techniques. *Proceedings of the 9th International Conference on Software Engineering*, 328–338. https://doi.org/10.5555/41765.41801

Rule, A. C., Stefanich, G. P., Boody, R. M., & Peiffer, B. (2011). Impact of Adaptive Materials on Teachers and their Students with Visual Impairments in Secondary Science and Mathematics Classes. *International Journal of Science Education, 33*(6), 865–887. https://doi.org/10.1080/09500693.2010.506619

Saljo, R. (2010). Digital tools and challenges to institutional traditions of learning: technologies, social memory and the performative nature of learning. *Journal of Computer Assisted Learning, 26*(1), 53–64. https://doi.org/10.1111/j.1365-2729.2009.00341.x

Sanders, E. B. N., & Westerlund, B. (2011). Experiencing, exploring and experimenting in and with co-design spaces. *Nordes*, (4), 298-302.

Sanders, E. B.-N., & Stappers, P. J. (2008). Co-creation and the new landscapes of design. *CoDesign, 4*(1), 5–18. https://doi.org/10.1080/15710880701875068

Sanger, C. S., & Gleason, N. W. (2020). Culture and Learning: Confucian Heritage Learners, Social-Oriented Achievement, and Innovative Pedagogies. In *Diversity and Inclusion in Global Higher Education*. Palgrave Macmillan. https://doi.org/10.1007/978-981-15-1628-3_5

Sangiorgi, D., Vink, J., Farr, M., Mulvale, G., & Warwick, L. (2022). Designing as negotiating across logic multiplicity: The case of mental healthcare transformation toward co-design and co-production. *International Journal of Design, 16*(1), 35-54. https://doi.org/10.57698/v16i1.03

Sannino, A., & Engeström, Y. (2018). Cultural-historical activity theory: Founding insights and new challenges. *Kul'turno-Istoricheskai︠a︡ Psikhologii︠a, 14*(3), 43–56. https://doi.org/10.17759/chp.2018140304

Sat, M., & Cagiltay, K. (2025). Empowering teachers' professional development with e-textiles supported educational STEAM projects. *International Journal of Technology and Design Education, 35*(1), 209–232. https://doi.org/10.1007/s10798-024-09892-8

SASSVI. (2025, Oct 11). *Statewide Support Services*. https://sassvi.sa.edu.au/services/statewide-support-services/

Savin-Baden, M. & Major, C.H. (2013) *Qualitative research: The essential guide to theory and practice*. Routledge.

Schmidt, M., Newbutt, N., Lee, M., Lu, J., Francois, M.-S., Antonenko, P. D., & Glaser, N. (2024). Toward a strengths-based model for designing virtual reality learning experiences for autistic users. *Autism : The International Journal of Research and Practice, 28*(7), 1809–1827. https://doi.org/10.1177/13623613231208579

Schneider, O., MacLean, K., Swindells, C., & Booth, K. (2017). Haptic experience design: What hapticians do and where they need help. *International Journal of Human-Computer Studies*, 107, 5–21. https://doi.org/10.1016/j.ijhcs.2017.04.004

Schroeder, C. M. (2023). *Coming in from the Margins: Faculty Development's Emerging Organizational Development Role in Institutional Change* (C. Schroeder, Ed.; First edition.). Routledge. https://doi.org/10.4324/9781003443476

Schwoerer, K., Keppeler, F., Mussagulova, A., & Puello, S. (2022). CO-DESIGN-ing a more context-based, pluralistic, and participatory future for public administration. *Public Administration (London), 100*(1), 72–97. https://doi.org/10.1111/padm.12828

Schön, D. A. (1983). *The reflective practitioner: how professionals think in action.* Basic Books.

Schön, D. A. (1987). *Educating the reflective practitioner*. Jossey-Bass.

Scoppio, G., & Luyt, I. (2017). Mind the gap: Enabling online faculty and instructional designers in mapping new models for quality online courses. *Education and Information Technologies, 22*(3), 725–746. https://doi.org/10.1007/s10639-015-9452-y

Scott, S. S., Loewen, G., Funckes, C., & Kroeger, S. (2003). Implementing Universal Design in Higher Education: Moving beyond the Built Environment. *Journal of Postsecondary Education and Disability, 16*(2), 78-89.

Sfard, A. (1998). On Two Metaphors for Learning and the Dangers of Choosing Just One. *Educational Researcher, 27*(2), 4–13. https://doi.org/10.3102/0013189X027002004

Shai, P. N. (2020). A Local Researcher's Experiences of the Insider–Outsider Position: An Exercise of Self-Reflexivity During Ethnographic GBV and HIV Prevention Research in South Africa. *International Journal of Qualitative Methods, 19*. https://doi.org/10.1177/1609406920938563

Sheppard, L., & Aldrich, F. K. (2001). Tactile graphics in school education: perspectives from teachers. *The British Journal of Visual Impairment, 19*(3), 93–97. https://doi.org/10.1177/026461960101900303

Shih, W.-C., Tseng, S.-S., & Yang, C.-T. (2008). Wiki-based rapid prototyping for teaching-material design in e-Learning grids. *Computers and Education, 51*(3), 1037–1057. https://doi.org/10.1016/j.compedu.2007.10.007

Shove, E., Pantzar, M., & Watson, M. (2012). *The Dynamics of Social Practice: Everyday Life and How It Changes* (1st ed). SAGE Publications, Limited.

https://doi.org/10.4135/9781446250655

Silberman, R. K., & Sacks, S. (2000). Expansion of the role of the teacher of students with visual impairments: Providing for students who also have severe/multiple disabilities. In *Foundations of education: Volume 2. Instructional strategies for teaching children and youths with visual impairments* (pp. 785-791). New York: American Foundation for the Blind Press.

Silberman, R. K., & Sacks, S. (Eds.). (1998). *Educating students who have visual impairments with other disabilities*. Paul H. Brookes Publishing Company.

Simmel, G. (1909). The Problem of Sociology. *The American Journal of Sociology, 15*(5), 289-.

Simon, H. A. (Herbert A. (1969). *The sciences of the artificial*. M.I.T. Press.

Smagorinsky, P. (2012). *Vygotsky and Literacy Research*. Springer.

Smith, K. A., & Herlich, S. (2014). Separated by a Driveway: Collaboration between Two State Specialized Schools to Assess Students with Deafblindness. *Journal of Visual Impairment & Blindness, 108*(6), 501–505. https://doi.org/10.1177/0145482X1410800609

Soles, D. E. (1985). Locke's Empiricism and the Postulation of Unobservables. *Journal of the History of Philosophy, 23*(3), 339-369.

South Australian Department for Education. (2025a, Oct 11). *Designing signage to help people find their way*. https://www.education.sa.gov.au/working-us/builders-design-and-maintenance/designing-buildings-and-spaces-everyone/designing-signage-help-people-find-their-way

South Australian Department for Education. (2025a, Oct 11). *Designing the size and shape of indoor and outdoor spaces*. https://www.education.sa.gov.au/working-us/builders-design-and-maintenance/designing-buildings-and-spaces-everyone/designing-size-and-shape-indoor-and-outdoor-spaces

Spungin, S. J., & Ferrali, K. A. (2000). The role and function of the teacher of students with visual handicaps. In *Foundations of education: Instructional strategies for teaching children and youths with visual impairments* (2nd ed., Vol. 2, pp. 785-791). New York: American Foundation for the Blind.

Spungin, S. J., & Ferrell, K. A. (2000). The role and function of the teacher of students with visual handicaps. In *Foundations of education: Volume 2. Instructional strategies for* *teaching children and youths with visual impairments* (pp. 785-791). New York: American Foundation for the Blind Press.

Spungin, S. J., & Taylor, J. L. (1986). The teacher. In *Foundations of education for blind and visually handicapped children and youth: Theory and practice* (pp. 255–264). New York: American Foundation for the Blind.

Stake, R. E. (1995). *The art of case study research*. Sage Publications.

Stake, R. E., Denzin, N. K., & Lincoln, Y. S. (2000). *Handbook of qualitative research*. SAGE Publications

Stappers, P. J. (2014). Prototypes as a central vein for knowledge development. In *Prototype: Design and craft in the 21st century* (pp. 85-97). Bloomsbury Academic.

Star, S. L. (2010). This is Not a Boundary Object: Reflections on the Origin of a Concept. S*cience, Technology, & Human Values, 35*(5), 601–617. https://doi.org/10.1177/0162243910377624

Stavholm, E., Mackley, H., Caughey, J., Heard, A., & Edwards, S. (2024). Co-design with children, families, and educators for understanding children's digital life-worlds for play and learning. *CoDesign*, 1–16. https://doi.org/10.1080/15710882.2024.2427011

Steen, M. (2013). Co-Design as a Process of Joint Inquiry and Imagination. *Design Issues, 29*(2), 16–28. https://doi.org/10.1162/DESI_a_00207

Stevenson, H. W., Azuma, H., Hakuta, K., Center for Advanced Study in the Behavioral Sciences, & Stevenson, H. W. (Harold W. (1986). *Child development and education in Japan*. W.H. Freeman.

Suchman, L. (1993). Working relations of technology production and use. *Computer Supported Cooperative Work, 2*(1–2), 21–39. https://doi.org/10.1007/BF00749282

Suchman, L. A. (1987). *Plans and situated actions : the problem of human-machine communication.* Cambridge University Press.

Suhendra, F., & St John, N. (2025). Enacting Pluriversal Design Education: The Importance of Positionality and Intersectionality in Practice. *Design Issues, 41*(3), 94 – 113. https://doi.org/10.1162/DESI.a.8

Suter, W. N. (2012). *Introduction to educational research a critical thinking approach* (2nd ed.). SAGE.

Suvak, P. A. (2004). What do they really do? Activities of teachers of students with visual impairments. *RE:View (Washington, D.C.), 36*(1), 22-31.

Sweller, J. (2024). Cognitive load theory and individual differences. *Learning and Individual Differences, 110*, Article 102423. https://doi.org/10.1016/j.lindif.2024.102423

Swenson, A. M. (1995). Itinerant Teaching: An Insider's View. *RE:View (Washington, D.C.), 27*(3), 113-117.

Syafril, S., Asril, Z., Engkizar, E., Zafirah, A., Agusti, F. A., & Sugiharta, I. (2021). Designing prototype model of virtual geometry in mathematics learning using augmented reality. *IOP Conference Series: Earth and Environmental Science, 1796*(1), 12035-. https://doi.org/10.1088/1742-6596/1796/1/012035

Sørensen, E. (2009). *The materiality of learning : technology and knowledge in educational practice* (1st ed.). Cambridge University Press.

Taffe, S. (2015). The hybrid designer/end-user: Revealing paradoxes in co-design. *Design Studies, 40*, 39–59. https://doi.org/10.1016/j.destud.2015.06.003

Taoka, Y., Kagohashi, K., & Mougenot, C. (2021). A cross-cultural study of co-design: the impact of power distance on group dynamics in Japan. *CoDesign, 17*(1), 22–49. https://doi.org/10.1080/15710882.2018.1546321

Taylor, C. (1985). *Philosophy and the human sciences*. Cambridge University Press.

Thabrew, H., Fleming, T., Hetrick, S., & Merry, S. (2018). Co-design of eHealth Interventions With Children and Young People. *Frontiers in Psychiatry, 9*, 481–481. https://doi.org/10.3389/fpsyt.2018.00481

Thevin, L., Brock, A. M., Kouroupetroglou, G., Miesenberger, K., Miesenberger, K., & Kouroupetroglou, G. (2018). Augmented Reality for People with Visual Impairments: Designing and Creating Audio-Tactile Content from Existing Objects. In *Computers Helping People with Special Needs* (Vol. 10897, pp. 193–200). Springer International Publishing AG. https://doi.org/10.1007/978-3-319-94274-2_26

Thomson, P., ProQuest, & ProQuest. (2002). *Schooling the rustbelt kids making the difference in changing times*. Allen & Unwin.

Thorpe, A., & Gamman, L. (2011). Design with society: why socially responsive design is good enough. *CoDesign, 7*(3–4), 217–230. https://doi.org/10.1080/15710882.2011.630477

Tight, M. (2010). The curious case of case study: a viewpoint. *International Journal of Social Research Methodology, 13*(4), 329–339. https://doi.org/10.1080/13645570903187181

Tilley, C. Y. (2006). *Handbook of material culture*. SAGE.

Tilley, S. A. (2003). “Challenging” Research Practices: Turning a Critical Lens on the Work of Transcription. *Qualitative Inquiry, 9*(5), 750–773. https://doi.org/10.1177/1077800403255296

Tomasello, M. (1999). *The cultural origins of human cognition*. Harvard University Press.

Tomasello, M., Carpenter, M., Call, J., Behne, T., & Moll, H. (2005). Understanding and sharing intentions: The origins of cultural cognition. *The Behavioral and Brain Sciences, 28*(5), 675–691. https://doi.org/10.1017/S0140525X05000129

Toppano, E. (2010). A communication-based model of ontology design and (re)use. *ACM International Conference Proceeding Series*, 1–7. https://doi.org/10.1145/1874590.1874596

Treagust, D. F., Won, M., Lederman, J. S., Lederman, N. G., & Zeidler, D. L. (2023). Paradigms in Science Education Research. In *Handbook of Research on Science Education*: *Vol. III* (1st ed., pp. 3–27). Routledge. https://doi.org/10.4324/9780367855758-2

Trent, S. C., Artiles, A. J., & Englert, C. S. (1998). From deficit thinking to social constructivism: A review of theory, research, and practice in special education. *Review of Research in Education, 23*, 277–307. https://doi.org/10.3102/0091732x023001277

Trischler, J., Dietrich, T., & Rundle-Thiele, S. (2019). Co-design: from expert- to user-driven ideas in public service design. *Public Management Review, 21*(11), 1595–1619. https://doi.org/10.1080/14719037.2019.1619810

Turnbull, A. P. (1995). *Exceptional lives: Special education in today's schools*. Merrill/Prentice Hall, Order Department, 200 Old Tappan Rd., Old Tappan, NJ 07675..

Vallee, D. (2017). Student engagement and inclusive education: reframing student engagement. *International Journal of Inclusive Education, 21*(9), 920–937. https://doi.org/10.1080/13603116.2017.1296033

Van Mechelen, M., Laenen, A., Zaman, B., Willems, B., & Abeele, V. V. (2019). Collaborative Design Thinking (CoDeT): A co-design approach for high child-to-adult ratios. *International Journal of Human-Computer Studies, 130*, 179–195. https://doi.org/10.1016/j.ijhcs.2019.06.013

Vinter, A., Orlandi, O., & Morgan, P. (2020). Identification of Textured Tactile Pictures in Visually Impaired and Blindfolded Sighted Children. *Frontiers in Psychology, 11*, 345–345. https://doi.org/10.3389/fpsyg.2020.00345

Vongkulluksn, V. W., Matewos, A. M., Sinatra, G. M., & Marsh, J. A. (2018). Motivational factors in makerspaces: a mixed methods study of elementary school students' situational interest, self-efficacy, and achievement emotions. *International Journal of STEM Education, 5*(1), 43–19. https://doi.org/10.1186/s40594-018-0129-0

Voogt, J. M., Pieters, J. M., & Handelzalts, A. (2016). Teacher collaboration in curriculum design teams: effects, mechanisms, and conditions. *Educational Research and Evaluation, 22*(3–4), 121–140. https://doi.org/10.1080/13803611.2016.1247725

Voogt, J., Laferrière, T., Breuleux, A., Itow, R. C., Hickey, D. T., & McKenney, S. (2015). Collaborative design as a form of professional development. *Instructional Science, 43*(2), 259–282. https://doi.org/10.1007/s11251-014-9340-7

Vygodskaya, G. L. (1999). Vygotsky and Problems of Special Education. *Remedial and Special Education, 20*(6), 330–332. https://doi.org/10.1177/074193259902000605

Vygotsky, L. S. (1978). *Mind in society : the development of higher psychological processes*. Harvard University Press.

Vygotsky, L. S., Rieber, R. W., & Carton, A. S. (1993). *The Collected Works of L. S. Vygotsky: The Fundamentals of Defectology (Abnormal Psychology and Learning Disabilities)* (1st ed.). Springer.

Walden, R. (2009). *Schools for the future : design proposals from architectural psychology*. Hogrefe & Huber.

Wang, T.-L., & Lien, Y.-H. B. (2012). The power of using video data. *Quality & Quantity, 47*(5), 2933–2941. https://doi.org/10.1007/s11135-012-9717-0

Wang, T., & McLaughlin, C. (2024). Promoting learner-centred education amid the culture of test-based accountability: insights from a cross-cultural teacher education programme. *Comparative Education*, 1 – 20. https://doi.org/10.1080/03050068.2024.2423445

Watchorn, V., Tucker, R., Hitch, D., & Frawley, P. (2024). Co-design in the context of universal design: An Australian case study exploring the role of people with disabilities in the design of public buildings. *The Design Journal, 27*(1), 68 – 88. https://doi.org/10.1080/14606925.2023.2264652

Webster, A., & Roe, J. (1998). *Children with visual impairments : social interaction, language and learning* (1st ed.). Routledge. https://doi.org/10.4324/9780203440971

Wells, G. (1999). *Dialogic Inquiry: Towards a Socio-cultural Practice and Theory of*

Education (1st ed.). Cambridge University Press. https://doi.org/10.1017/CBO9780511605895

Wenger, E. (1999). *Communities of practice : learning, meaning, and identity* (First paperback edition.). Cambridge University Press.

Wensveen, S., & Matthews, B. (2015). Prototypes and prototyping in design research. In *The routledge companion to design research* (pp. 262-276). Routledge.

Wertsch, J. V. (1981). *The Concept of activity in Soviet psychology*. M.E. Sharpe.

Wertsch, J. V. (1990). The voice of rationality in a sociocultural approach to mind. In *Vygotsky and Education* (pp. 111–126). Cambridge University Press. https://doi.org/10.1017/CBO9781139173674.006

Whitchurch, C. (2008). Shifting identities and blurring boundaries: The emergence of third space professionals in UK higher education. *Higher Education Quarterly, 62*(4), 377–396. https://doi.org/10.1111/j.1468-2273.2008.00387.x

Williamson, B. (2019). *Accessible America : A History of Disability and Design*. New York University Press,. https://doi.org/10.18574/9781479855582

Willis, A.-M. (2006). Ontological Designing. *Design Philosophy Papers, 4*(2), 69–92. https://doi.org/10.2752/144871306X13966268131514

Wong, C.-C., Kumpulainen, K., & Kajamaa, A. (2021). Collaborative creativity among education professionals in a co-design workshop: A multidimensional analysis. *Thinking Skills and Creativity, 42*, 100971-. https://doi.org/10.1016/j.tsc.2021.100971

Wrigley, C., & Straker, K. (2017). Design Thinking pedagogy: the Educational Design Ladder. *Innovations in Education and Teaching International, 54*(4), 374–385. https://doi.org/10.1080/14703297.2015.1108214

Yin, R. K. (1984). *Case study research : design and methods*. Sage Publications.

Yin, R. K. (2018). *Case study research and applications : design and methods* (Sixth edition.). SAGE.

Yip, J. C., Sobel, K., Pitt, C., Lee, K. J., Chen, S., Nasu, K., & Pina, L. R. (2017, May). Examining adult-child interactions in intergenerational participatory design. In *Proceedings of the 2017 CHI conference on human factors in computing systems* (pp. 5742-5754).

Yu, F., & Eng Wong, B. (2025). Confucian Culture: The Scapegoat of Chinese EFL Students'

Unwillingness to Communicate. *Journal of Language Teaching, Linguistics, and Literature, 31*(1), 339 – 357. https://doi.org/10.17576/3L-2025-3101-22

Zahorik, P., & Jenison, R. L. (1998). Presence as Being-in-the-World. *Presence : Teleoperators and Virtual Environment, 7*(1), 78–89. https://doi.org/10.1162/105474698565541

Zebehazy, K. T., & Wilton, A. P. (2014). Quality, Importance, and Instruction: The Perspectives of Teachers of Students with Visual Impairments on Graphics Use by Students. *Journal of Visual Impairment & Blindness, 108*(1), 5–16. https://doi.org/10.1177/0145482X1410800102

Zechmeister-Koss, I., Aufhammer, S., Bachler, H., Bauer, A., Bechter, P., Buchheim, A., Christiansen, H., Fischer, M., Franz, M., Fuchs, M., Goodyear, M., Gruber, N., Hofer, A., Hölzle, L., Juen, E., Papanthimou, F., Prokop, M., & Paul, J. L. (2023). Practices to support co-design processes: A case-study of co-designing a program for children with parents with a mental health problem in the Austrian region of Tyrol. *International Journal of Mental Health Nursing, 32*(1), 223–235. https://doi.org/10.1111/inm.13078

Zeng, L., Weber, G., Esposito, A. M., Esposito, A., Vinciarelli, A., Müller, V. C., & Hoffmann, R. (2012). ATMap: Annotated Tactile Maps for the Visually Impaired. In *Cognitive Behavioural Systems* (Vol. 7403, pp. 290–298). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-34584-5_25

Örnekoğlu-Selçuk, M., Emmanouil, M., Hasirci, D., Grizioti, M., & Van Langenhove, L. (2024). A systematic literature review on co-design education and preparing future designers for their role in co-design. *CoDesign, 20*(2), 351–366. https://doi.org/10.1080/15710882.2023.2242840

Appendices

Appendix A: Participant information letter

Participant Information Letter

Research Project Title: Co-design as Pedagogy: Identifying Materiality, Designed Form, and Learning Activities with/for Visually Impaired Children

To whom it may concern:

You are being invited to take part in a research project. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask the researcher if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

Purpose of the study:
The purpose of this study is to explore how co-design processes can improve learning materials and activities specifically for visually impaired children. The research aims to investigate how teachers, designers, children, and learning materials interact in the co-design process. Through understanding these interactions, the study seeks to develop inclusive, meaningful, and effective educational practices and resources that support visually impaired children's learning experiences.

What will happen if you take part in the study:
If you agree to participate, your involvement may include one or more of the following activities:

- Participating in interviews or group discussions regarding your experiences, views, and strategies for designing learning materials for visually impaired children. Interviews typically last 10-30 minutes.
- Allowing observations of your teaching or design sessions in a natural classroom or workshop setting.
- Participating in co-design workshops that involve designing or prototyping educational materials or activities alongside visually impaired children, teachers, and designers. Each workshop may last approximately 2-3 hours.
- You may be invited to review or provide feedback on materials or resources developed during the research.

For children’s parents/guardians:

Firstly, let me assure you that your child's privacy, safety, and wellbeing are our top priorities. As researchers, we adhere to strict ethical guidelines and data protection measures to ensure the utmost confidentiality of personal information. You have the right to know the details of the study before giving consent, and you also have the right to withdraw from the study at any time when your child wants to without any adverse consequences.

Potential risks and benefits:
There are no known risks associated with this task. Whilst there are no immediate benefits for those people participating in the project, it is hoped that this work will: improved academic performance, social and emotional development, and the final results of research after the participant has assisted in the completion of the study will also give the participant a pride in having contributed to the research themselves.

Confidentiality:
The participants' information will be kept strictly confidential and stored separately from the research data. All the information will be made completed anonymously. The anonymised data will only be available to others as peer-reviewed scientific journals, conference papers, book chapters and the researcher' s PhD thesis. The publications will be available online.

All the contact information that researcher collect about you during the research will be kept strictly confidential and will stored separately from the research data. The researcher will take steps wherever possible to anonymise the research data so that you will not be identified in any reports or publications.

The results of the study may be published before May 2025 and the participates can obtain a copy of the published results. Again, the participates will not be identified in any report or publication.

Withdrawal:
Your participation in this study is voluntary, and you have the right to withdraw at any time without giving a reason. If you decide to withdraw, any data collected up to that point will be destroyed and will not be used in the study.

Contact for further information:
If you have any questions about the study or your participation, please contact the researcher: +86 18600371992/+44 07960704289.
Thank you for taking the time to read through the information.

Consent:
I confirm that I have read and understood the information provided above, and I agree to participate in this study.

Signature:

Print Name:
Date:

Appendix B: Informed consent form

Co-design as Pedagogy: Identifying Materiality, Designed Form, and Learning Activities with/for Visually Impaired Children	Add your initials next to the statement if you agree
I confirm that I have obtained the consent of my child and sign this consent form on behalf of my child.	
I confirm that both my child and I have read and understand the information letter dated (May, 2023) explaining the above research project and we have had the opportunity to ask questions about the project.	
We understand that the participation is voluntary and that my child free to withdraw at any time without giving any reason until the project finish and without there being any negative consequences. In addition, should the child not wish to answer any particular question or questions, he/she is free to decline. Researcher contact number: +86 18600371992/+44 07960704289 Typically, once a participant withdraws from the study, any data collected up to that point will be retained by the researcher. The researcher will ensure that the participant's data is anonymised, meaning that any identifying information is removed, and the data is de-identified.	
We understand that members of the research team may have access to child's responses. We understand that our name will not be linked with the research materials, and we will not be identified or identifiable in the report or reports that result from the research. We understand that child's responses will be kept strictly confidential.	
We understand that the data collected from the child may be stored and used in relevant future research in an anonymised form.	
We understand that relevant sections of the data collected during the study, may be looked at by individuals from the University of Leeds or from regulatory authorities where it is relevant to my taking part in this research.	
We agree to take part in the above research project and will inform the lead researcher should my contact details change.	

Name of participant (child)	
Name of participant's guardian	
Participant's guardian's signature	
Date	
Name of lead researcher	
Signature	
Date*	

*To be signed and dated in the presence of the participant.

Once this has been signed by all parties the participant should receive a copy of the signed and dated participant consent form, the letter/ pre-written script/ information sheet and any other written information provided to the participants. A copy of the signed and dated consent form should be kept with the project's main documents which must be kept in a secure location.

Appendix C: Recruitment letter

Anqi Rong
University of Leeds
Leeds, LS2 9JT, United Kingdom
sdar@leeds.ac.uk
+44 07960704289

Recruitment Letter

Subject: Invitation to Participate in Research Study - Identifying Materiality, Designed Form, and Learning Activities with/for Visually Impaired Children

To whom it may concern,

I hope this letter finds you well.

I am writing to invite *[School/Organisation Name]* to participate in a research study focused on identifying co-design with visually impaired children. We believe that your collaboration will greatly contribute to advancing our understanding of the needs and preferences of visually impaired children in this context.

The aim of this study is to explore how co-design processes can improve learning materials and activities specifically for visually impaired children. The research aims to investigate how teachers, designers, children, and learning materials interact in the co-design process. Through understanding these interactions, the study seeks to develop inclusive, meaningful, and effective educational practices and resources that support visually impaired children's learning experiences.

Here are some key details about the research study:

1. Purpose: The study aims to offer insights that can empower designers and educators to rethink how educational experiences are crafted and how children, particularly those with disabilities, can be seen as active participants in shaping their own learning journeys.
2. Participants: We are seeking the participation of visually impaired children aged [5-10] who are currently enrolled in school.
3. Involvement: Participating in the study would involve allowing researchers to conduct observations, interviews, and workshopss with children. The research team will work closely with the school/organisation to ensure minimal disruption to the regular curriculum and activities.
4. Benefits: By participating in this study, your school/organisation will have the opportunity to contribute to research that can enhance educational practices and resources for visually impaired children. Additionally, you will receive a summary of the research findings, which can support your ongoing efforts in providing high-quality education to visually impaired students.

5. Confidentiality: All data collected during the research study will be treated with strict confidentiality. Personal information and identities of participants will be anonymised to ensure privacy and data protection.

We kindly request your support in distributing the attached participant information letter to parents/guardians of visually impaired children. This letter provides more detailed information about the study, its objectives, and the procedures involved. We would greatly appreciate it if you could assist in obtaining informed consent from interested parents/guardians.

If you have any questions or require further information, please do not hesitate to contact me. We believe that this research has the potential to make a significant positive impact on the lives of visually impaired children, and your partnership is crucial in achieving this goal.

Thank you for considering this invitation, and we look forward to the possibility of collaborating with [School/Organisation Name] for this important research study.

Sincerely,

Anqi Rong
School of Design
University of Leeds

Appendix D: Interview protocols

<u>Interview protocol for teachers</u>

1. Interview details

Participant:
Age:
Date and time of interview:
Total time taken:

2. Introduction

Hello [name of participant], thank you for agreeing to participate in this study, your contribution and time is much appreciated. As you have been informed, in this project I'm interested in exploring teachers' practices and approaches to the pedagogical design for visually impaired children. So that I can concentrate on our conversation rather than take notes, I would like to record our discussion. Is that okay with you?

[*Start Recording*]

3. Interview questions

What is your primary teaching area?
How do you learn about the special needs of visually impaired children?
How do you delve deeper into their needs or emotions?
What challenges do these children often face in their daily life and studies?
Do you have any memorable stories from your daily teaching to share?

What do you think are the main educational challenges faced by visually impaired children?
Based on your experience, what are the primary needs of these children?
When interacting with visually impaired children, what do you think is the most important communication skill?
How do you cultivate other senses in visually impaired children, such as touch?
What is the primary challenge you face when teaching visual concepts to visually impaired children?

Do you have any innovative teaching strategies or methods that are particularly suitable for visually impaired children?
What aspects of the future educational environment do you believe can be further optimised or innovated to meet the needs of these children?
Have you discussed any new teaching methods or resources with other teachers or parents?
Or do you have partners or teams involved in the design and production of teaching materials?
When the learning content requires learning materials, how do you choose and create them?
What kind of resources or assistance is most beneficial to you?

In which specific subjects or themes do you believe tactile materials and teaching aids are particularly useful?

What factors do you first consider when designing and creating teaching materials?
When testing new teaching aids or methods, how do you evaluate their effectiveness? How do you determine if the child has mastered the skill/knowledge?
Have you encountered any failed instances related to teaching materials or methods?

Have children or their parents ever provided feedback on different teaching materials or methods?
After testing a new teaching materials or methods, do you make adjustments or optimisations?
Generally, how long does it take to test whether a teaching material or method is effective (e.g., after one modification or several)?

Lastly, are there any issues you hope to address?

Interview protocol for experts

Expert 1:

1. How did you get into the industry and what sparked your interest in this work?
2. What important changes have taken place in China's Braille publishing industry in the past few years?
3. What are some of the more important considerations you take into account when designing large print textbooks and tactile books?
4. How many categories can tactile books be divided into?
5. Is the Chinese market currently dominated by machine-made tactile books or handcrafted tactile books? Why?
6. What are the main challenges encountered in the current development of mechanically produced and handmade tactile books in China?
7. In your article, you summarised the main steps in making a tactile book as conceptualising, drawing, processing, lettering and binding, are there any details in these steps that are particularly important and need attention?
8. At present, the production of handmade tactile books is a combination of Finnish and Russian standards (2011) or so, are there any updated production standards in China now?
9. What are the main needs of visually impaired children for books in China today?
10. Is there any geographical or cultural diversity in the use of curriculum materials and tactile books in China?
11. What are the current major selections for large print books? Are there any challenges?
12. How do you think about the impact of digitisation on Braille publications?
13. What is the positive impact of these curriculum materials on the education of visually impaired children?
14. What suggestions or ideas do you have for visually impaired library services?
15. What is your expectation or vision for the future development of Braille books in China?
16. Do you have any advice for people who want to work in related fields?

Expert 2:

1. How did you first get interested in tactile graphic design and sensory fusion design? What appeals to you personally about these fields?
2. What do you think is the most critical design principle in tactile graphics design? Why?
3. How has your research impacted the learning experience of visually impaired students, particularly in the use of tactile materials?
4. How do you ensure balance and harmonisation between different sensory inputs in sensory integration design?
5. Can you share some specific projects or case studies about your work in tactile graphics design?
6. What do you think are the main challenges still facing the current field of tactile graphics design?

7. How important do you think feedback from visually impaired people involved in the design process is? How did their participation change your design thinking?
8. In your research on the psychology of design, what psychological factors have you found to have a significant impact on the effectiveness of tactile graphics design?
9. How would you assess the friendliness of current curriculum materials for visually impaired students? Is there space for improvement?
10. Is there a gap between theory and practical application of tactile graphics design in your research? How can this gap be bridged?
11. Have you been involved in interdisciplinary research projects? How have these projects contributed to innovation in tactile graphics design?
12. What do you see as the potential for AI and machine learning techniques to be used in tactile graphics design?
13. How are your research results communicated to other researchers, designers or educators? What are some specific examples of application?
14. For future research directions, what other areas do you think tactile graphics design and sensory integration design could explore to further serve the visually impaired population?
15. Are any of your students also interested in this field? What are their ideas?
16. Do you have any advice for people who want to pursue related research?

Expert 3:

1. How did you first become interested in tactile graphics design and accessible design? What is the special significance of these areas for you?
2. What has been the main focus of your research in the area of tactile graphics design? What are the implications of this research for the visually impaired?
3. What elements of tactile graphics design do you think are most critical to the experience of the visually impaired?
4. What do you think about the current situation of tactile graphics design in China? What are the areas for improvement?
5. Can you share a tactile graphics design project that you worked on? What challenges did you face in this project and how did you overcome them?
6. What do you think is the role of tactile graphics design in the education of visually impaired children? What success stories can you share?
7. How has your research influenced the social engagement of visually impaired people, especially in public spaces such as schools?
8. How do you assess the effectiveness of tactile graphics designs? Are there any specific evaluation methods or tools that have been used?
9. Have you encountered difficulties in converting traditional designs into tactile graphics designs? How do you solve these problems?
10. In your research, how do you balance aesthetics and functionality to ensure that the design is equally friendly to visually impaired and non-visually impaired people?
11. What do you think is the potential of AI and machine learning techniques in tactile graphics design?

12. In your research on tactile graphics design, have you identified certain general design principles? How do these principles guide your design practice?
13. How do you see the impact of policies and regulations on accessible design? How do these policies help or limit design practice?
14. When working with visually impaired people, what feedback do you find most enhances the practical application of the design?
15. For future research directions, in what other areas do you think the combination of tactile graphics design can achieve breakthroughs?
16. Do you have any advice for people who want to work in related fields?

Interview protocol for VIC

Short interview:

1. Can you tell me your name and age?
2. Can you tell me who your best friend is?
3. What is your favourite class?
4. What do you usually like to touch with your hands?
5. What kind of sense of touch do you like the most? (Maybe you don't quite understand the question, for example, do you like soft or hard?)
6. What don't you like to touch?
7. Is there anything else you would like to learn or understand besides what you usually learn in class?
8. Do you like tactile books? Why?
9. What do you find the hardest in maths? Is it shapes or numbers?

Group interview:

1. What has each child learnt through this time?
2. Have you been upset at any time during your studies?
3. What do you think is the hardest problem for you?
4. Can we summarise the good points of each student together?
5. Do you think it is difficult for you to read Braille in class?
6. Is there anything you would like your teacher to improve?

Appendix E: Observation guide

1. General information

Date:
Participants:
Setting:
Duration of the observation:

2. Indicative points for attention

1) Participant Roles and Engagement
Who is actively participating or leading the activity?
How do VIC engage with materials (touch, sound, etc.)?
Are there distinct roles (teacher, designer, children) that emerge during activities?

2) Interactions and Communication
Forms of communication (verbal, non-verbal, tactile, or assistive technology).
Language used (clarifying questions, instructions, negotiations).
Moments of conflict or misunderstanding—how are they resolved?

3) Tools and Materials
Types of materials used (e.g., tactile prototypes, digital tools, Braille resources).
How are these materials adapted or modified over time?
Participant feedback on tool effectiveness or usability.

4) Decisions and Adaptations
Key junctures where activities change direction or pace.
Who initiates these changes, and on what basis?
Effects of changes on group dynamics, learning outcomes, or design progress.

5) Reflections and Interpretations
Initial interpretations or inferences about the efficacy of each category of activity.
Connections to broader research questions or theoretical frameworks (e.g., sociocultural context, co-design principles).
Potential follow-up questions or areas requiring deeper inquiry.

Appendix F: Workshops plan

Workshop 1 (20 Oct, 2023)

Theme: The calendar for the Year of the Dragon

1.Welcome and Introduction (10 minutes)
Objective: To create a welcoming environment and introduce the workshop theme.
Activities:

- Greet participants and introduce facilitators.
- Brief overview of the workshop objectives.
- Explain the importance of the Year of the Dragon in Chinese culture, using tactile and audio materials.
- Introduce the concept of a calendar and its significance in tracking important cultural events.

2. Icebreaker Activity: Exploring Traditional Chinese Culture (20 minutes)
Objective: To familiarise children with key elements of traditional Chinese culture.
Activities:

- Use tactile materials and audio cues to introduce elements of the dragon.
- Children are encouraged to share what they know or have experienced related to Chinese culture related to the dragon.

3. Brainstorming Session: Designing the Calendar (10 minutes)
Objective: To collaboratively generate ideas for the calendar's design.
Activities:

- Discuss what elements should be included in the calendar (e.g., dragon imagery, zodiac signs, festival dates).
- Facilitators guide children in expressing their ideas through tactile and verbal means.
- Use tactile models (e.g., dragon scales) to inspire creativity.
- Record children's ideas for later reference.

4. Hands-on Co-Design Activity (60 minutes)
Objective: To collaboratively create a tactile prototype of the calendar.
Activities:

- Divide children into small groups, each focusing on a specific part of the dragon .
- Provide tactile materials and guide children in creating tactile elements for the dragon.
- Encourage children to feel and describe their work, ensuring all contributions are captured.
- Use audio descriptions and traditional music to enhance the atmosphere.

5. Sharing and Feedback (20 minutes)
Objective: To review the created prototypes and gather feedback.

Activities:

- Each child presents their part of the dragon to the whole group, using tactile and verbal descriptions.
- Facilitators provide positive feedback and ask guiding questions to encourage further reflection.
- Collect feedback on what worked well and what could be improved.

6. Closing Reflection (10 minutes)

Objective: To reflect on the workshop experience and discuss the next steps.

Activities:

- Gather participants for a final discussion.
- Ask children what they enjoyed most and what they learned about the dragon and traditional Chinese culture.
- Explain the next steps for refining the calendar design and how their contributions will be used.
- Distribute small tokens of appreciation (e.g., tactile dragon figures, Braille cards with cultural facts).

7. Wrap-up and Goodbyes (10 minutes)

Objective: To conclude the workshop on a positive note.

Activities:

- Thank participants for their creativity and hard work.
- Provide contact information for any follow-up questions or additional support.
- Distribute take-home materials related to the workshop theme.

Workshop 2 (31 Oct, 2023)

Theme: The Underwater World

1. Welcome and Introduction (10 minutes)
Objective: To create a welcoming environment and introduce the workshop theme.
Activities:
- Greet participants and introduce facilitators.
- Brief overview of the workshop objectives.
- Explain the theme of the “Underwater World” and why oceans are important.
- Use tactile materials and audio effects to introduce ocean elements (e.g., play ocean sounds and let children feel wet sponges to represent water).

2. Icebreaker Activity: Exploring the Ocean (15 minutes)
Objective: To familiarise children with different underwater elements through sensory engagement.
Activities:
- Introduce ocean-related textures: let children feel materials like smooth shells, rough sandpaper (to represent coral), soft foam (for seaweed), and clay (for sea creatures).
- Play sound effects of different sea creatures and encourage children to guess what they are.
- Encourage children to share what they already know about the sea and their favorite ocean animals.

3. Brainstorming Session: Creating an Underwater Scene (15 minutes)
Objective: To collaboratively generate ideas for an interactive underwater world.
Activities:
- Discuss what elements should be included in an underwater scene (e.g., fish, seaweed, coral, waves).
- Facilitators guide children in expressing their ideas through tactile and verbal means.
- Use tactile prototypes (e.g., different textures for fish scales) to inspire creativity.
- Record children’s ideas for later reference.

4. Hands-on Co-Design Activity (90 minutes)
Objective: To collaboratively create a tactile representation of the underwater world.
Activities:
- Provide different materials and guide children in using them to create ocean-themed objects.
- Use foam and textured paper to create seaweed and coral.
- Mold clay into different sea creatures.
- Layer different textures to represent ocean currents.
- Play background ocean sounds while children work.
- Encourage them to describe how their designs feel and why they chose certain textures.

5. Sharing and Feedback (25 minutes)
Objective: To review the created tactile underwater world and gather feedback.
Activities:

- Each child presents their part of the underwater scene to the whole group using tactile and verbal descriptions.
- Facilitators provide positive feedback and ask guiding questions to encourage deeper reflection.
- Collect feedback on what worked well and what could be improved.

6. Closing Reflection (15 minutes)
Objective: To reflect on the workshop experience and discuss the next steps.
Activities:

- Gather participants for a final discussion.
- Ask children what they enjoyed most and what they learned about the underwater world.
- Discuss how their creations could be used in future activities or exhibitions.
- Distribute small tokens of appreciation (e.g., tactile ocean-themed objects like shell-shaped figures and Braille cards with marine facts).

7. Wrap-up and Goodbyes (10 minutes)
Objective: To conclude the workshop on a positive note.
Activities:

- Thank participants for their creativity and hard work.
- Provide contact information for any follow-up questions or additional support.
- Distribute take-home materials related to the workshop theme.

Appendix G: Basic information form for visually impaired children

<table>
<tr><th colspan="9">Basic Information</th></tr>
<tr><td colspan="2">Name</td><td colspan="2"></td><td>Gender</td><td></td><td>Age</td><td></td><td rowspan="4">Photo</td></tr>
<tr><td colspan="2">Date of Birth</td><td colspan="2"></td><td>Height</td><td></td><td>Weight</td><td></td></tr>
<tr><td colspan="2">Identification Number</td><td colspan="2"></td><td>Ethnicity</td><td></td><td>Origin</td><td></td></tr>
<tr><td colspan="2">Disability Certificate Number</td><td colspan="2"></td><td>Category</td><td></td><td>Level</td><td></td></tr>
<tr><td colspan="2">Address</td><td colspan="7"></td></tr>
<tr><td colspan="2">Personal Habits and Preferences</td><td colspan="2"></td><td colspan="2">Interests and Talents</td><td colspan="3"></td></tr>
<tr><td colspan="2">Personality</td><td colspan="2"></td><td colspan="2">Preferred Games and Toys</td><td colspan="3"></td></tr>
<tr><td colspan="2">Favourite People and Sounds</td><td colspan="2"></td><td colspan="2">Favourite Places</td><td colspan="3"></td></tr>
<tr><td colspan="2">Favourite Foods</td><td colspan="2"></td><td colspan="2">Food/Medication Allergies</td><td colspan="3"></td></tr>
<tr><td colspan="2">Medical History</td><td colspan="2"></td><td colspan="2">Current Health Conditions</td><td colspan="3"></td></tr>
<tr><td colspan="2">Visual Condition (detailed description)</td><td colspan="7"></td></tr>
<tr><td>Visual Acuity</td><td colspan="8">Left Eye_____ Right eye
□Index □Light perception □blindness</td></tr>
<tr><td>Assistive Devices</td><td colspan="8">☐Glasses ☐Visual aids ☐Light-filtering glasses
☐Near-vision optical magnifier Magnification
☐Long-distance monocular telescope Magnification</td></tr>
<tr><td rowspan="2">Current Educational Placement</td><td colspan="3">☐Staying at home</td><td colspan="3">☐School for the Blind (preschool)</td><td colspan="2">☐Regular school/ kindergarten</td></tr>
<tr><td colspan="3">☐Residential care</td><td colspan="5">☐Other</td></tr>
<tr><td rowspan="2">Primary Companion in Beijing</td><td colspan="2">☐Mother</td><td>☐Father</td><td colspan="3">☐Grandparents (paternal)</td><td colspan="2">☐Grandparents (maternal)</td></tr>
<tr><td colspan="3">☐Relatives</td><td colspan="3">☐Domestic helper</td><td colspan="2">☐Other</td></tr>
</table>

Personal Abilities				
Daily Living Skills	☐Dressing ☐toothbrushing ☐eating ☐dishwashing ☐toileting ☐self-cleaning after toileting ☐putting on shoes ☐nail clipping ☐organising school bag ☐washing personal clothing ☐Other			
Instruction Compliance	☐Fully cooperative	☐Mostly cooperative	☐Non-cooperative	☐Other
Language Ability	☐Normal spoken language		☐Imitative speech	
	☐Simple sign language		☐No spoken language	
	☐Other			
Basic Cognitive Ability	☐Recognises familiar people ☐Identifies common objects ☐Familiar with frequently visited environments ☐Has basic concepts of shape, size, weight, height, quantity, width, etc. ☐Recognises numbers up to 10 and numerical (quantity) relationships ☐Understands concepts of time, space, directions, order, and sequence ☐Other			
Auditory Ability	☐Identifies familiar/common object sounds ☐Identifies sounds direction			
Fine Motor Skills	☐One hand stabilizing, one hand operating ☐Coordinated two-hand use ☐Tactile discrimination ☐Line tracking Grasp: ☐Palmar grasp ☐three-finger pinch ☐pincer grip ☐Arm, hand, and finger strength ☐Finger differentiation and coordination ☐Finger coordination ☐Other			
Mobility	☐Independent walking	☐Walking with single-hand guidance	☐Unable to walk	
O & M Skills	☐Uses white cane (☐indoors ☐outdoors)		☐Does not use white cane	
Adaptation to External Environments	☐Fully adapts to new environments	☐Cries or resists in new environments	☐Experiences motion sickness	
Social Interaction Skills	☐Willing to interact with peers ☐Resolves conflicts with peers independently ☐Polite in social interactions ☐Actively participates and enjoys group activities ☐Abides by group rules independently ☐Other			
Learning Situation				
Braille Reading and Writing	☐No exposure at all			
	☐Can recite Braille dot positions ☐Can read Braille (six-dot) ☐Can write Braille (six-dot) ☐Knows Braille initials and finals (reading) ☐Knows Braille initials and finals (writing) ☐Knows Braille writing rules			
	☐Proficient in reading and writing Braille			

Mathematical Thinking	☐Can detect simple arrangement patterns and attempts creating new patterns ☐Understands practical meanings of “addition” and “subtraction” ☐Performs addition and subtraction within 10 through objects or other methods ☐Can distinguish left from right ☐Other	
English Ability	☐No exposure at all	☐Some exposure, but not formally studied
	☐Understands meanings of common words and phrases	☐Capable of simple conversations in English