

Designing for Interdisciplinary Teaching and Learning in Higher Education

A Phenomenographic Study of Course Leaders' Experiences

Dwayne Ripley

B.A. (English Lit.), M.L.S.T. (Research)

Submitted in fulfilment of the requirements for the degree of Doctor of Philosophy

School of Education and Social Work

Learning Sciences

The University of Sydney

2025

Keywords

Interdisciplinarity, Interdisciplinary education, Educational design, Interdisciplinary teaching and learning, Knowledge creation, Phenomenography, Higher education

The award of a Research Training Program scholarship to the PhD Candidate supported the research reported in this thesis.

Author's Declaration

This is to certify that to the best of my knowledge; the content of this thesis is my work. This thesis has not been submitted for any degree or other purposes. All the assistance received in preparing this thesis and sources have been acknowledged.

Signature:

Name: Dwayne Ripley

Abstract

Interdisciplinarity has become a core aim of many universities, resulting in the expansion of interdisciplinary courses that prepare students to live and work in a world marked by increasing complexity, uncertainty, and rapid technological advancement. However, there remains limited clarity and agreement on the meanings, purposes, and practices of interdisciplinary education. This thesis aims to create useful knowledge on designing for interdisciplinary teaching and learning by identifying and mapping out the variation in course leaders' understandings, conceptions, and experiences. It employs a phenomenographic approach to investigate different aspects of academics' experiences of designing for interdisciplinary teaching and learning through semi-structured interviews with 23 academics who made substantial intellectual contributions to the conceptualisation, creation, design, redesign, or enactment of interdisciplinary courses. These academics have backgrounds that are representative of the breadth of faculties and disciplinary structures at a comprehensive Australian university. I refer to these academics as 'course leaders' in this thesis.

To research course leaders' experiences of designing for interdisciplinary teaching and learning, I investigate five aspects: (1) how course leaders understand interdisciplinarity, (2) how they conceive of its purpose in interdisciplinary education, (3) how they approach interdisciplinary teaching and learning in their course designs, (4) how they experience educational design processes, and (5) how they experience their institutional environment when developing and sustaining interdisciplinary courses. Together these five areas of inquiry help to develop an extensive understanding of how course leaders experience designing for interdisciplinary teaching and learning in higher education.

My analysis of the five research questions and the analysis of the relationships between them makes an original and significant contribution to understanding the variation in

how course leaders experience designing for interdisciplinary teaching and learning in higher education. This adds to the body of research in this area in ways that individual accounts of practice and evidence synthesis approaches cannot — it enables exploration of the relationships between different ways of experiencing designing across a shared setting and presents them in logical structures (outcome spaces) that contribute novel insights into interdisciplinary design experiences.

This thesis shows that course leaders experiences designing for interdisciplinary teaching and learning are characterised by variation, however, they show that their experiences are collaborative, knowledge-centred, and necessitate ongoing learning. Further, the outcomes of the thesis report on *how* interdisciplinary course leaders experience designing as situated, how plurality is experienced in relation to the individual and collective construction of understandings, purposes, approaches, processes, and environments, and how course leaders address the challenges they face in practice. These outcomes extend the body of research on design for interdisciplinary education by mapping out variations in practice and the relationships between them.

It highlights the importance of informal collegial networks that support designing for interdisciplinary teaching and learning, identifies the importance of conducting research to generate design knowledge, and positions interdisciplinary design work as epistemic work, not procedural work, noting the need to identify and acknowledge its practices to inform efforts to support and sustain them. The thesis discusses the potential for interdisciplinary design practices to contribute to shaping the university environments and presents the implications of the study's outcomes on interdisciplinary design practices and university systems. This thesis further presents how its outcomes can be of practical use to interdisciplinary course leaders and others responsible for creating and sustaining interdisciplinary courses and programmes in universities.

List of Publications Included in This Thesis

The format of this thesis is that of a thesis with publication. This thesis contains five journal articles, each one answering one of the five research questions listed above. This section contains the bibliographic information on the five articles that constitute five chapters in this thesis. The articles from Chapters 4 and 5 have been published. The articles from Chapters 6, 7, and 8 have been submitted for publication.

Chapter 4

Ripley, D., Markauskaite, L., & Goodyear, P. (2024). A phenomenographic exploration of course leaders' understandings of interdisciplinarity. *Studies in Higher Education*, 49(11), 2208–2221. <https://doi.org/10.1080/03075079.2023.2293932>

Published. Reproduced in this thesis with permission from Taylor & Francis. Open Access.

Chapter 5

Ripley, D., Markauskaite, L. (2024). Course leaders' conceptions of the purpose of interdisciplinary education. *Higher Education*. <https://doi.org/10.1007/s10734-024-01360-5>

Published. Reproduced in this thesis with permission from Springer Nature. Open Access.

Chapter 6

Ripley, D., & Markauskaite, L., & Goodyear, P. Variation in Approaches to Interdisciplinary Teaching and Learning: A Phenomenographic Investigation

Unpublished manuscript. Submitted to *Teaching in Higher Education*.

Chapter 7

Ripley, D., Markauskaite, L., & Goodyear, P. Interdisciplinary course design processes: A phenomenographic study of course leaders' experiences.

Unpublished manuscript. Submitted to *Instructional Science*.

Chapter 8

Ripley, D., Markauskaite, L., & Goodyear, P. Developing and sustaining interdisciplinary courses: Course leaders' experiences of their institutional environment

Unpublished manuscript. Submitted to *Higher Education Research and Development*.

Acknowledgments

Committing to a PhD is no small intellectual, emotional, psychological, or financial commitment. The toll it takes is distributed, affecting many people beyond the PhD candidate. To my wife and daughter who gave me the time, space, patience, and support at this stage in our lives to see the thesis through despite numerous sacrifices—thank you. I recognise that I’ve missed so many events, holidays, and time together with both of you. Cooking each night so we could share a meal was my way of coping with the PhD and ensuring that we had time together each day. I look forward to being available beyond our daily dinners now.

Committing to an interdisciplinary PhD can be even more daunting and may require a longer candidature, especially when completing a thesis with publications. Venturing into such an expansive, open-ended area of research demands a lot from any aspiring academic and a lot from the candidate’s primary supervisor. To Professor Lina Markauskaite, thank you for all of your patience and for continually bringing me back to solid ground each time I veered off course, struggled through data analysis, or repeated mistakes when writing. Early on in my candidature an education professor said in response to me mentioning that Lina was my supervisor, “She’s the most intelligent person in every room she enters”. I agree but what’s even more notable is your willingness to help people that are struggling, to bring people together, and to bring people along, helping them develop as academics. Lina, you are ethical, responsible, and diligent. I am a better thinker, a better researcher, and a better person for having your guidance and support over these many years. I can’t thank you enough for all of your help.

To my secondary supervisor Emeritus Professor Peter Goodyear, your level of expertise and your ability to craft elegant simple sentences are both humbling and inspirational. These qualities are clear to anyone who reads your work, but to those who have the opportunity to work with you, the patience and tact you show to aspiring researchers makes you even more impressive. Thank you for sharing your extensive expertise and wisdom and for how you communicate it as well. I appreciate how you use feedback as a teaching strategy, i.e., how you give feedback adopting the perspective of a ‘curmudgeonly’ editor.

To Dr. Natasha Arthars, I can't thank you enough for helping me throughout this experience. You've given me so much of your time and guided me through the transition into academia. I'd like to recognise the immense and diligent effort you put into editing and formatting my thesis in the weeks leading up to my submission. To have someone of your diligence and expertise helping to get me over the line was invaluable. You are such an impressive person and a true friend. Your support, guidance, and daily online chats have made the PhD experience only manageable but also enjoyable. We started learning together in the Masters of Learning Sciences and Technology as part-time students almost a decade ago, and I hope I can work together with you in and beyond academia for a long time into the future.

In my experience, PhDs are best done alongside others. Thank you to all of the wonderful people I have learned together with and worked alongside during my PhD candidature (Colin Simpson, Dr. Ling Wu, and Dr. Leela Cejnar among many others), including the CRLI/Cocolab members, the ARC *Developing Interdisciplinary Expertise in Universities* research team, the PGARC students, the Sydney Business School, and my co-editors and co-authors in the *Creating Design Knowledge in Educational Innovation* book.

I also look forward to spending more time reconnecting with my parents, brothers, and friends scattered around the world. I've become a bit of a hermit as a coping mechanism and I'm looking forward to changing that.

I would especially like to thank all of the study's participants. I truly respect the effort and care that you put into your work. I hope that I've honestly captured and communicated your experiences so that others can learn from them.

Lastly, I would like to acknowledge the funding I have benefitted from, including the Australian Research Council through [Discovery Project grant DP200100376](#) (Developing interdisciplinary expertise in universities), the RTP scholarship, PRSS funding, and the Paulette Isabel Jones PhD completion scholarship. I hope that this thesis gives back to the higher education system in Australia and internationally.

Table of Contents

Author's Declaration	ii
Abstract	iii
List of Publications Included in This Thesis	v
Acknowledgments	vi
List of Figures	x
List of Tables	xi
Glossary	xii
Chapter 1: Introduction	1
1.1 Educational Design for Interdisciplinary Teaching and Learning	2
1.2 Research Aims and Questions	6
1.3 Significance of the Study	7
1.4 Scope and Limitations	8
1.5 Outline of the Thesis	9
Chapter 2: Conceptual Background	11
2.1 The Problem	11
2.2 The Concepts	12
Chapter 3: Methodology	22
3.1 Phenomenography	22
3.2 The Phenomenographic Outcome Space	28
3.3 Research Design	29
Chapter 4: A Phenomenographic Exploration of Course Leaders' Understandings of Interdisciplinarity	42
Chapter 5: Course Leaders' Conceptions of the Purpose of Interdisciplinary Education	57
Chapter 6: Variation in Approaches to Interdisciplinary Teaching and Learning: A Phenomenographic Investigation	78
Chapter 7: Interdisciplinary Course Design Processes: A Phenomenographic Study of Course Leaders' Experiences	107
Chapter 8: Developing and sustaining interdisciplinary courses: Course leaders' experiences of their institutional environment	137
Chapter 9: Discussion	164
9.1 Summary of the Main Outcomes	164
9.2 Synthesis of Outcomes	172
Chapter 10: Conclusions	181

10.1 Contributions to knowledge.....	181
10.2 Limitations	187
This section discusses the limitations of the thesis concerning the selection of participants, the methods utilised, and the applicability of the outcomes.	187
10.3 Future Research.....	188
10.4 Concluding Remarks.....	189
References	191
Appendices	201
Appendix A: Participant Information Statement	202
Appendix B. Participant Consent Form	207
Appendix C. Interview Schedule	209
Appendix D. Human Ethics Modifications.....	211

List of Figures

Figure 2.1 A visual representation of the five interrelated areas of inquiry

Figure 3.1. Participants' disciplinary backgrounds

Figure 3.2 Participants' years of experience in academia and leading interdisciplinary courses

Figure 3.3 The ACAD wireframe (Adapted from Goodyear et al., 2021)

Figure 6.1 Activity centred analysis and design (ACAD) design model (from Markauskaite & Goodyear, 2017, p. 609)

Figure 7.1 ACAD framework (adapted from Carvalho & Goodyear, 2018)

Figure 8.1 ACAD wireframe (adapted from Goodyear et al., 2021)

Figure D1. Ethics approval email to add Dwayne Ripley to the research project

Figure D2. Ethics approval email to add units of study to the research project

Figure D3. Ethics approval attachment to add units of study to the research project

List of Tables

Table 1. Profiles of study participants

Table 2. Outcome space: course leaders' understandings of interdisciplinarity and variations between them.

Table 3. Referential and structural components of course leaders' understandings of interdisciplinarity.

Table 5.1. Profiles of study participants (Listed as Table 1 in Chapter 5)

Table 5.2 Conceptions of the purpose of interdisciplinary education (Listed as Table 2 in Chapter 5)

Table 6.1 Profiles of study participants

Table 6.2 Outcome space: Course leaders' approaches to interdisciplinary teaching and learning in course designs

Table 7.1 Profiles of study participants

Table 7.2 Course leaders' experiences of interdisciplinary course design processes

Table 8.1 Profiles of study participants

Table 8.2 Course leaders' experiences of their institutional environments when developing and sustaining interdisciplinary courses

Table 9.1.1 Summary of Outcomes: How do leaders of interdisciplinary courses understand interdisciplinarity?

Table 9.1.2 Summary of Outcomes: How do interdisciplinary course leaders conceive of the purpose of interdisciplinary education?

Table 9.1.3 Summary of Outcomes: How do course leaders approach teaching and learning when designing interdisciplinary courses?

Table 9.1.4 Summary of Outcomes: How do course leaders experience educational design processes when developing interdisciplinary courses?

Table 9.1.5 Summary of Outcomes: How do course leaders experience their institutional environments when developing and sustaining interdisciplinary courses?

Glossary

Approaches to Teaching and Learning: In phenomenographic research, the term *approaches* refers to how people go about something (Marton & Booth, 1997). In this thesis, it refers to how course leaders go about teaching and learning in their interdisciplinary course designs.

Courses: In Australia, the term *unit of study* is commonly used to describe what is referred to as a *course* in many other countries. The term *course* has been used in this thesis in place of the term *unit of study* to make the research more easily understood to a global audience.¹

Designing: Throughout the thesis, the term *designing* is used to provide clarity that it is the practice of design (verb) that is being investigated. The term *design* can be both a verb and a noun. For clarity, in Chapter 6, it is experienced in relation to course designs (noun) that are being investigated, so the term *design* is used at times in the thesis.

Design Knowledge: Design knowledge is knowledge that is of practical use for educational design. In this thesis, I describe design knowledge as knowledge that is available that is practically useful to design practices. It is also referred to in relation to generating knowledge about design in course leaders' design practices.

Educational Design: Educational design is a term that is used synonymously with instructional design and design for learning (Ellis & Goodyear, 2019). It refers to pedagogical, logistical, and technical work done (Bennet et al., 2018) in advance of, during, and following teaching and learning activity (Bennett et al., 2017).

¹ I am a Canadian who has lived for long periods of time in Hong Kong, Taiwan, and Australia, studying a global phenomenon with supervisors who hail from Europe. My spelling conventions and the language I use do not conform to any 'standard', however, I have tried to keep them consistent, and I have attempted to justify their use in this thesis.

Epistemic Agency: The capacity that enables a person to intentionally engage in activities related to the production of knowledge (Damsa et al., 2010). This term is used to refer to students' development of capabilities to work with different disciplinary ways of creating knowledge, enabling them to productively, and knowledgeably engage in such activities.

Epistemic practices: Epistemic practices are “the socially organized and interactionally accomplished ways that members of a group propose, communicate, justify, assess, and legitimize knowledge claims” (Cunningham & Kelly, 2017, p. 487). They are the practices that underlie dynamic knowledge co-construction that are essential to interdisciplinary teamwork.

Institutional Environment: The term institutional environment is used in this thesis to emphasise the focus on the university system course leaders inhabit and interact with during their design practices.

Interdisciplinarity: Interdisciplinarity is often defined with other taxonomic terms used to describe the different forms of disciplinary exchange, including ‘multidisciplinarity’, ‘interdisciplinarity’, and ‘transdisciplinarity’ (Nikitina, 2005). In this thesis, it is used as a general term to refer to all such forms of disciplinary exchange and “collaboration between disciplines and other non-academic knowledge fields and activity spheres such as community, industry, politics and private life” (Markauskaite et al., 2024, p. 4).

Phenomenography: Phenomenography is a theoretical perspective and a methodological approach for conducting qualitative research to investigate variation in how a group of people collectively understand, conceptualise, and/or experience a phenomenon (Marton, 1987).

Chapter 1: Introduction

As the world becomes increasingly more interconnected, complex, and driven by rapid technological change, universities are adapting to effectively prepare students for new jobs and new ways of working. Graduate employability is a key objective of Australian universities (Oliver & Jorre de St Jorre, 2018; Small et al., 2022), with an emphasis on preparing students for work in the knowledge economy. However, many aspects of work have taken on an epistemic quality and involve the creation of new knowledge (Goodyear & Markauskaite, 2019; Knorr-Cetina, 2001).

At the same time, there is a demand to prepare students as engaged citizens, ready and capable of addressing wicked problems,² problems that are dynamic and continuously changing, are complex and do not have established problem-solving methods. Such problems include climate change and widening economic inequality (Kawa et al., 2021). They are problems that cannot be addressed by any single person or discipline alone. Although interdisciplinarity is not new, it has the potential to transform the relationships between science, technology, and society to address wicked problems, making it a recent focus of attention in both research and education (Barry & Born, 2013).

The rise of knowledge work and the need for universities to further engage with societal issues in education have prompted universities to generate more interdisciplinary offerings for students (Stentoft, 2019). This has resulted in the addition of interdisciplinary courses³ within academic structures established to support disciplinary learning (Kidron & Kali, 2023). The rise of interdisciplinarity in universities has prompted organisational

² Building upon Rittle & Webber's (1973) definition, Goodyear and Markauskaite (2019) describe wicked problems as problems that in addition to being complex, difficult, and persistent, they are rarely solvable, wherein formulation of wicked problems is considered to be an integral part of the problem.

³ A course is defined as a single subject within a larger qualification, such as an undergraduate degree. In this study, the term *course* is used which is equivalent to the term *unit of study* often used in Australia.

changes, despite universities being characteristically resistant to change (Weingart, 2014). However, the scope and commitment to interdisciplinary education can vary within and across universities (Holley & Szostak, 2022) and interdisciplinary education can emerge in different forms (Lyall et al., 2016). The course leaders⁴ responsible for developing and sustaining interdisciplinary courses within an institution may have widely different design experiences.

In this thesis, whereas *developing* refers to the initial creation of a course in this thesis, the term *sustaining* refers to the ongoing design work to adapt, enhance, and iterate upon the course to enable it to be continually enacted in various adaptations over time. As interdisciplinary courses become more established and mainstream in universities, it is paramount that universities ensure the efficacy, quality, and sustainability of interdisciplinary courses.

1.1 Educational Design for Interdisciplinary Teaching and Learning

Educational design⁵ for interdisciplinary teaching and learning can be daunting for course leaders who are responsible for developing and sustaining interdisciplinary courses due to the complexity of designing for interdisciplinary teaching and learning. They may not be prepared to work with different disciplinary discourses and epistemologies (Ashby & Exter, 2019) and may face challenges if they need to work in interdisciplinary design teams (Bopardikar et al., 2021). McKenney et al. (2015) argue that as design⁶ becomes more complex and sophisticated, more collaboration and larger design teams are required.

⁴ The individuals who make substantial intellectual contributions to the conceptualisation, creation, design or redesign, or enactment of courses are referred to as *course leaders*.

⁵ Educational design is a term that is often used synonymously with instructional design and design for learning (Ellis & Goodyear, 2019).

⁶ The term design can be both verb and noun. In the thesis, the term *designing* is used to indicate that it is the practice that is being investigated, however, the term *design* can be used to refer to common use in, or in relation to the literature. Additionally, Chapter 6 focuses on the noun, *design*, whereas the other chapters focus on the verb, *designing*.

However, the responsibility of designing for interdisciplinary courses is often left to individual academics (Lindvig et al., 2019) who are rarely afforded sufficient institutional guidance and support (Lyall et al., 2016). There is therefore a need for design knowledge⁷; knowledge that is of practical use for educational design, to support design for interdisciplinary teaching and learning.

There are several reasons why course leaders need practical knowledge that can be useful to them for designing for interdisciplinary teaching and learning. Much of the peer-reviewed literature on interdisciplinarity offers little concrete guidance on practices (van Goch, 2024). A significant amount of literature specific to empirical studies of interdisciplinary teaching exists in blogs and other grey literature, making it difficult to find, and what is available in peer-reviewed journals is largely focused on aspirational and theoretical propositions of interdisciplinary teaching rather than on empirical descriptions of interdisciplinary teaching practices (Lindvig & Ulriksen, 2019). There is a scarcity of research that can support academics tasked with developing and enacting interdisciplinary courses.⁸

First, the predominant pedagogies used in interdisciplinary teaching and learning are constructivist, often centred on students' project-based learning (Lyall et al., 2016; Markauskaite et al., 2024). Constructivist approaches can increase the demands placed upon teachers due to the need to be flexible to facilitate open-ended learning activities (Millar, 2016). Despite their prominence, interdisciplinary teaching and learning does not have any unique or established set of pedagogies (DeZure, 2017; Klein, 2010). This can add complexity to and amplify the existing pedagogical challenges teachers face (Vienni Baptista

⁷ In this thesis I describe design knowledge as *know-how* that is useful for design practices. It is developed through research on design activity and inscribed into principles and other forms that can be of practical use to designers.

⁸ I have been significantly involved in the design of interdisciplinary courses at different universities in Australia and have conducted research on educational design. Despite having significant support, I was initially unsure where and how to find resources and useful literature on how to design.

et al., 2024). Markauskaite et al. (2024) express that interdisciplinary learning is under-theorised and under-researched. This thesis presents a spectrum of ways that course leaders approach interdisciplinary teaching and learning. For example, Chapter 6 illustrates the variation in approaches that course leaders take in their course designs. This can be useful to people responsible for designing for interdisciplinary courses and activities. They can draw on and compare potential approaches they may employ in their course designs.

Second, in addition to variation in what course leaders design for, there is variation in the design processes course leaders use to create and iterate upon course designs. There is a growing body of research that frames interdisciplinary educational practices as multiple and situated (Lindvig & Ulriksen, 2019; Øland et al., 2023; Vienni Baptista et al., 2024). Studies include the investigation of varying *purposes, approaches, and designs* of interdisciplinary teaching and learning (Lindvig & Ulriksen, 2019), the investigation of varying *configurations* of interdisciplinary education across educational levels (Øland et al., 2023), and the investigation into interdisciplinary educational *practices* in universities (Vienni Baptista et al., 2024). This thesis contributes insights that enhance our understanding of the variation in how course leaders experience designing for interdisciplinary teaching and learning and the relationships between different ways of experiencing it. In Chapter 7, this thesis investigates and contributes insights into design processes that are used to design and redesign interdisciplinary courses.

Third, design always takes place within a context with competing purposes, practices, and priorities. Haggis (2003) argues that phenomenographic research can present a narrow view of how a phenomenon is experienced due to a lack of engagement with the complexities of location and context. Brew et al. (2022) identify the need for phenomenographic research to account for the wider context in which educational practices take place, emphasising that academics operate within complex, dynamic environments that have a significant influence

on educational practices. For example, interdisciplinary courses are resource-intensive and easy targets to cut in times of austerity (Lyall et al., 2016), making it important to ensure they are an effective use of resources. Further, interdisciplinarity has been described as “exacerbated by hype and overstatement, both pro and con” (Graff, 2016, p. 788), and as a ‘buzzword’ (Holley & Szostak, 2022). This precarity is coupled with the importance of its mission – to prepare students to address the social ills of a dynamic, complex, and interconnected society. In Chapter 8, this thesis investigates the relationship between designing and the wider institutional environment within which designing for interdisciplinary teaching and learning takes place. This thesis does not make claims regarding the institutional context (its history, culture, strategies, systems, and diverse practices); however, it does expand the focus of research beyond a pedagogical focus to investigate course leaders’ experiences of designing for interdisciplinary teaching and learning with an explicit awareness of social, physical, and epistemic aspects of designing across micro (course), meso (design processes), and macro (the institutional environment). This will be presented in further detail (Section 3.3).

Lastly, it is important to broaden the view of who designs. Design can involve teachers, university staff, students, and others who can shape or influence design practices. Goodyear (2018) argues that to ensure the sustainability of educational approaches in higher education, rigorous evidence is needed to support the ways that approaches are understood, motivated, and implemented. For interdisciplinary design, this includes the generation, sharing, and building upon knowledge about design. This is required to build an institutional capacity for educational design which can help universities to anticipate and address changes in their operating environments (Goodyear, 2015). This thesis aims to create design knowledge that can be useful to interdisciplinary teachers, programme managers, educational designers, and even students as well as, university leadership, and policymakers. It is

admittedly a wide audience because designing for interdisciplinary teaching and learning involves a wide spectrum of people, and this thesis takes a wide perspective when considering what and who is involved in designing for interdisciplinary teaching and learning. An empirical foundation is necessary to support designing for interdisciplinary teaching and learning to ensure the quality and longevity of interdisciplinary courses. This thesis aims to raise awareness of how designing for interdisciplinary teaching and learning is experienced to achieve this.

1.2 Research Aims and Questions

In this study, interdisciplinary teaching and learning practices are conceptualised as plural and situated in nature. This thesis does not identify any single correct or best way of designing for interdisciplinary teaching and learning. Instead, it aims to report on how designing for interdisciplinary teaching and learning is *experienced*. In doing so, this thesis contributes a rich understanding of the *variation* in how designing for interdisciplinary teaching and learning is experienced at a university.

The main overarching research question is: *How do course leaders experience designing for interdisciplinary teaching and learning in higher education?*

This thesis answers this main research question by using a phenomenographic approach to investigate five interrelated questions:

1. How do leaders of interdisciplinary courses understand interdisciplinarity?
2. How do interdisciplinary course leaders conceive of the purpose of interdisciplinary education?
3. How do course leaders approach teaching and learning when designing interdisciplinary courses?
4. How do course leaders experience educational design processes when developing interdisciplinary courses?

5. How do course leaders experience their institutional environments when developing and sustaining interdisciplinary courses?

By exploring the variation in experiences of course leaders across the five interrelated questions, this thesis connects the various aspects of experiences of designing for interdisciplinary teaching and learning including (1) understandings, (2) conceptions of purpose, (3) approaches to interdisciplinary teaching and learning, (4) design processes, and (5) developing and sustaining courses in the institutional environment.

For each area of inquiry, the structural relationships are explored, mapped out, and illustrated in a phenomenographic outcome space that answers the specific research question. Each outcome space presents the outcomes of the inquiry in a logical structure advancing from categories representing less to more awareness of the phenomenon of designing for interdisciplinary teaching and learning. Details regarding the methodological design will be elaborated upon in Chapter 3.

1.3 Significance of the Study

This study focuses on the variation in practitioners' experiences of designing for interdisciplinary teaching and learning, rather than on longstanding debates on definitions, taxonomies, and theoretical assumptions in interdisciplinary education. In doing so, this study contributes to the limited research on design for interdisciplinary teaching and learning that has been identified as necessary for the development of interdisciplinary education in universities (Ashby & Exter, 2019; DeZure, 2017). Conceptualising interdisciplinary teaching and learning as multiple and situated in nature (Lindvig & Ulriksen, 2019; Øland et al., 2023) and acknowledging that interdisciplinary education is undertheorized and under-researched at present (Markauskaite et al., 2024), this thesis does not presuppose there is any one right or best way of designing for interdisciplinary teaching and learning. Instead, it aims to report on

the collective ways designing is experienced and to explore and map out the relationships between the different ways of experiencing. Reporting on variance in interdisciplinary educational practices is not new, however, this thesis moves beyond the synthesis of disparate accounts to investigate the spectrum of ways that designing for interdisciplinary teaching and learning is experienced across a single institutional environment, enabling investigation of the relationships between different ways of experiencing designing for interdisciplinary teaching and learning.

1.4 Scope and Limitations

This research is a part of the Developing Interdisciplinary Expertise in Universities project – which was funded by the Australian Research Council (Discovery project grant DP200100376). Further information on this project can be found at <https://interdisciplinaryexpertise.org/>. The scope of this thesis falls under the umbrella of the ARC study which is set at the University of Sydney.

This thesis is constructed as a thesis with publications. Its empirical part is comprised of five published or publishable articles which act as individual chapters. Each article reports one of five outcome spaces that show the variation in aspects of how designing for interdisciplinary teaching and learning is experienced. In addition to exploring course leaders' understandings of interdisciplinarity and conceptions of the purpose of interdisciplinarity in education as a foundation (Chapters 4 and 5)⁹, the thesis investigates aspects of course designs, course design processes, and course design environments (Chapters 6, 7, and 8). Together, the outcomes from the investigation of the five research

⁹ In Australia, a thesis *by* publication is not an acceptable format, whereas thesis *with* publication is permissible, but requires the articles to contribute chapters to the thesis as a cohesive whole. Chapters 4 and 5 are published and provide the foundation for Chapters 6, 7, and 8 which were submitted to journals later on in the PhD candidature.

questions and their relationships contribute knowledge that expands our awareness of design for interdisciplinary teaching and learning.

Drawing on semi-structured interviews with 23 academic course leaders from diverse disciplinary backgrounds, the thesis contributes an extensive view of how course leaders collectively experience designing for interdisciplinary teaching and learning. Any approach that relies on what participants *say* about their practices but does not *observe* their practices is unable to capture the entirety of such practices (Kane et al., 2002). Nor would it be feasible to do so within the scope of a doctoral thesis. However, the approach taken has enabled the investigation of the course leaders' experiences with multiple aspects of designing for interdisciplinary teaching and learning. This scope was appropriate for a doctoral thesis and the aim, was to study variation, acknowledging that interdisciplinary courses can vary significantly.

1.5 Outline of the Thesis

The next chapter, Chapter 2, presents the conceptual background, defining key concepts and situating the research within the current theoretical and empirical literature.¹⁰

Chapter 3 argues that a phenomenographic approach is most appropriate and presents a description of and justification for the study's design, and the methods used for the different research questions.¹¹ Justification and explanation are also given for how the phenomenographic approach is used concerning the different research questions.

Chapters 4 through 8 consist of five articles written for publication. Each of the five articles report on different interrelated aspects of how designing for interdisciplinary teaching

¹⁰ The conceptual background chapter is supplemented by five individual literature reviews, one for each of the five articles in Chapters 4, 5, 6, 7, and 8.

¹¹ The methodology sections of each of the articles (Chapters 4, 5, 6, 7, and 8) have an unavoidable repetition as the same interviews and analysis processes were used for each of the articles. Familiarity with the methodology in Chapter 3 will provide a sufficient overview for the methodology used in the five articles, with some small variation in each.

is experienced, including how interdisciplinarity is understood (Chapter 4), how its purpose is conceived of for interdisciplinary education (Chapter 5), how interdisciplinary teaching and learning is approached in course designs (Chapter 6), how design processes are experienced (Chapter 7), and how the development and sustainability of courses is experienced concerning the wider institutional environment (Chapter 8).

Chapter 9 summarises the outcomes from the five articles, synthesises them as a whole, and introduces implications for practice. Chapter 10 then presents the limitations of this study, makes recommendations for future research, and offers suggestions for practice.

Chapter 2: Conceptual Background

This chapter presents the conceptual background for the study and justifies the use of five research questions to answer the study's overarching research question: *How do course leaders experience designing for interdisciplinary teaching and learning in higher education?* This chapter explains how the five questions relate to one another and form a coherent whole. It begins by introducing the problem and then presents key concepts that establish the background for the study, including plurality, situated learning, learning as knowledge creation, and teaching as design, before describing how these concepts lay the foundation for the study.

2.1 The Problem

Interdisciplinary teaching and learning are characterised by variation. It takes multiple forms including workshops, activities, and undergraduate and postgraduate degree programmes (Lyall et al., 2016). The variation extends to the ways it is designed for and enacted by academics who may belong to a range of faculties and schools who have different epistemologies and ways of working with knowledge (Ashby & Exter, 2019).

There are different ways of approaching this variation in research on interdisciplinarity in higher education. In the humanities, there was a predominant focus on a unified paradigm of interdisciplinarity that employed rhetoric centred on 'holism' and 'universality'. However in the 1990s, this gave way to a focus on a critical paradigm of interdisciplinarity that employs rhetoric centred on 'plurality' and 'heterogeneity' (Klein, 2010). Despite much of the current research in higher education positioning interdisciplinary practices in education as multiple and situated (Øland et al., 2023; Vienni Baptista et al., 2020), a tendency to universalise research outcomes remains prevalent (Lindvig & Ulriksen,

2019). Using phenomenography to investigate and map out variation in experiences can identify differences in ways of experiencing; but more importantly, phenomenography must also explore and describe the relationships between different ways of experiencing (Åkerlind, 2024). A phenomenographic approach can be useful in exploring variation in ways of experiencing designing for interdisciplinary teaching and learning, and understanding their relationships, creating insights on how educational practices can be multiple and situated. This next section identifies why in this thesis, phenomenographic investigation was extended to include five different aspects of design experiences, enabling the exploration and mapping of relationships across course designs (Chapter 6), design processes (Chapter 7), and design environments (Chapter 8).

2.2 The Concepts

Plurality

Plurality is a fundamental concept in the investigation of variance in course leaders' experiences designing for interdisciplinary teaching and learning. The concept of scientific pluralism emerged from frustration with attempts to find unity in science, often through reductionist approaches that are at odds with the wide variance in disciplinary methods, concepts, ontological stances, and goals of scientific research (Ludwig & Ruphy, 2021). Menken and Keestra (2016) highlight that scientific inquiry requires plurality in the use of theories and methods, and argue that interdisciplinary knowledge work, by way of integrating different theories and methods, is by definition plural. At times, course leaders are required to work with other academics from different disciplinary backgrounds in design work (Bopardikar et al., 2021) and in teaching processes (Lansiquot, 2020). They are also co-creators of knowledge when working together with students, supporting, and guiding their interdisciplinary teamwork.

Students must also work with plurality. Interdisciplinary learning often involves integrating knowledge (de Greef et al., 2017; Klein, 2005). Students from different disciplines often work together on projects, creating knowledge to investigate and generate candidate solutions to complex problems that span disciplinary boundaries. Bearman and Ajjawi (2024) argue that students should learn to deal with multiplicity to prepare them to grapple with contradictions in real environments.

When framed with unified conceptions of interdisciplinarity, plurality may reflect discord, but Vienni Baptista et al. (2020) argue that plurality instead reflects the diversity in interdisciplinary research and education, and further argue that investigating this diversity is an important avenue of research. For design, Friesen et al. (2023) argue that both design and research on design should not converge and move towards standardisation, but rather that it should sustain plurality.

Situated Learning

Educational practices are situated in local contexts, manifesting in different forms (Øland et al., 2023; Vienni Baptista et al., 2022). For example, Vienni Baptista et al. (2022) position knowledge production, in both research and in learning as dependent upon institutional arrangements and conditions. Goodyear and Ellis (2020) describe learning in higher education as taking place in “a complex sociomaterial meshwork involving learners, teachers, curriculum materials, software tools, and the physical environment” (p. 107). This conception extends to dispositions and perceptions. Bennett et al. (2017) argue that educational design is influenced by the perceived capabilities and needs of students, the teachers’ own beliefs about teaching and learning, and institutional and disciplinary norms.

Further, learning is not only situated in institutional environments but is also constituted by the relationships between them (Fenwick et al., 2011). For instance, how

interdisciplinarity is understood can relate to conceptions of its purpose in interdisciplinary education. How its purpose is understood can influence how a course leader designs for interdisciplinary teaching and learning, and so on. Each area of inquiry in this thesis is related to the others and exploring and mapping out them with one another offers a comprehensive understanding of how designing for interdisciplinary teaching and learning is experienced. This conception is foundational to all five areas of inquiry in this thesis, but especially relevant to Chapters 6, 7, and 8. It is also important to note that learning is not limited to what students do but is characteristic of interdisciplinary design practices which are also situated.

So far, this section has positioned designing for interdisciplinary learning as involving different possible educational practices (plural) that can be enacted in different ways (situated). The next sections look at ways of conceptualising teaching, learning, and design, and the relationships between them. Central to this is the role of knowledge in teaching, learning, and design.

Learning as Knowledge Creation

Learning is understood in different ways. There are different metaphors that are useful in conveying how learning happens. Sfard (1998) introduced the learning as participation metaphor and the learning as acquisition metaphor, noting that they are complementary and each offer something “that the other cannot provide” (p. 10). Paavola and Hakkarainen (2005) contributed a third complementary metaphor, the knowledge creation metaphor, positioning learning as occurring through the collaborative creation of knowledge. Learning as knowledge creation involves sustained work on creating new knowledge which positions learning as involving cognitive, social, and object-oriented work (Paavola & Hakkarainen, 2021). Goodyear (2015) highlighted that there are tools in place to support learning as acquiring knowledge and participating in a social practice, but the same is not true of tools

for learning as knowledge creation, noting that “if learning is seen as a matter of collaborating in knowledge creation, then new tools are designed and created by students as a legitimate outcome of their work” (p. 44). Learning as knowledge creation therefore requires a different approach to design, one that accounts for students’ engagement in expansive knowledge creation activities and the creation of tools and processes in their learning activities. Markauskaite (2020) lays out the implications on the relationships between teachers, students, and knowledge for each metaphor, describing: (1) the teacher as the provider, the student as the recipient, and knowledge as a possession in the acquisition metaphor, (2) the teacher as an expert, the student an apprentice, and knowledge as accepted practice for the participation metaphor, and (3) the teacher as co-creator and co-learner, the student as a knowledge co-creator, and knowledge exists in the object created for the knowledge creation metaphor.

Interdisciplinary courses often have an interdisciplinary project component where students work together to create innovations or solve problems. To be considered for inclusion in the study, interdisciplinary courses (and therefore the course leaders associated with them) required a project-based learning component. The knowledge creation metaphor is therefore relevant to the investigation of designing for interdisciplinary teaching and learning because students must create new knowledge. Courses (and subsequently course leaders) that did not include a project-based interdisciplinary teamwork component were excluded from the study as they did not enable the exploration of the full spectrum of approaches to teaching and learning as they may omit learning as knowledge creation, thereby limiting the scope of investigation.

In interdisciplinary projects, their learning may involve acquiring knowledge and participating in processes of socialisation; however, learning is often concentrated on the co-creation of knowledge. In interdisciplinary knowledge co-creation, how knowledge is created

matters. Whereas disciplines work with established ways of creating knowledge, interdisciplinary knowledge co-creation is commonly centred on novel issues that do not have standard approaches to creating knowledge in service of addressing them. It involves co-constructing knowledge as well as co-constructing the practices used to create knowledge (Markauskaite, 2020). This requires that significant attention be given to design as knowledge creation involves specialised methods, tools, and theories, and takes place in different settings for different disciplines. Put another way, designing for interdisciplinary teaching and learning must account for the situated and open-ended nature of interdisciplinary knowledge work that is involved in its practices.

Teaching as Design

Three assumptions are foundational for investigating experiences of designing for interdisciplinary teaching and learning: (1) that design is not limited to the activities that take place in preparation for teaching, (2) that universities can help to develop designers' capabilities, and (3) that there is practical knowledge that can be beneficial to designers to support the development of a university's design capacity for interdisciplinary teaching and learning.

First, in his article on teaching as design, Goodyear (2015) positions design as being at the centre of the teaching and learning lifecycle, occurring before teaching and learning activity (in the form of planning or course development), during the enactment of a plan or course requiring flexibility in teaching and learning activity, and also following teaching and learning activity involving reflection and evaluation. However, in most countries, teacher education programmes rarely develop design expertise beyond the planning of lessons (McKenney et al., 2015).

Second, Goodyear (2015) argues that “evidence-informed, creative, design-based strategies will be needed if universities are to generate innovative repertoires of educational approaches to deal with, and ideally to anticipate, changes in their operating environments” (p. 37). *Teaching as design* assumes that design capacity should be developed among various staff, not just teachers which can help to build an institutional capacity for design. This includes *Third space* professionals¹² which fall outside of the scope of this thesis. When teaching extends to the co-creation of knowledge, students also engage in design and develop design capabilities. Goodyear (2015) also argues that universities that improve their support for teachers’ design work will be more capable of anticipating and responding to the changing needs of students. However, in a study of Australian teachers’ design processes, Bennett et al. (2017) found that participants do not reference the use of design models or frameworks, and do not consciously think of their work as design, nor do they describe their work in terms of design. They argue that if teacher design is to drive innovation in universities, training and support need to be made widely available.

Third, conducting research is central to a university’s ability to develop a design capacity for interdisciplinary teaching and learning. This entails conducting research on design practices and proactively producing, sharing, and building upon relevant knowledge. McKenney et al. (2015) identify the kinds of knowledge individual teachers may need to develop to prepare teachers as designers “tacit and explicit aspects of knowing that underpin their capacity to engage skilfully in design work across situations and contexts, including the capacity to learn to design in new unfamiliar situations (p. 183). This knowledge is referred to as design knowledge which Goodyear et al. (2023) describe as “knowledge tuned to the requirements of design work” (p. 65). Christensen and Markauskaite (2025) further describe

¹² Third space professionals (Whitchurch, 2013) include people who work between the professional and academic spheres of activity. This includes educational designers who provide substantial support to academics in their design work.

it as principled-practical knowledge that is useful to practitioners and researchers to guide them in the design of innovations in education. They identify that design knowledge can be created through research-first pathways that draw on theories or empirical evidence, or experience-first pathways that draw on design practices, user needs, or experiences.

Laurillard (2012) similarly advocates for teaching as a design science to build design knowledge and to develop teachers' competencies through an analytical approach to their design work as teachers.

Researching interdisciplinarity requires consideration of the local circumstances in which practices are situated. Ryberg et al. (2023) note that they “see interdisciplinarity as depending on specific circumstances and as shaped by human actions and words as well as non-human devices, such as technical instruments, digitisation or marking scales that regulate action and come to define how interdisciplinarity takes form in a given situation.” (p. 2).

Researching course leaders' experiences of designing for interdisciplinary teaching and learning, investigating the situated nature of their practices and how they use design knowledge and create design knowledge in them can provide valuable insights into how interdisciplinary courses are *configured*¹³. The concept of teaching as design is useful to look not only at configurations that exist, but the design processes that are used to consciously configure interdisciplinary course designs, interdisciplinary course design processes, and environments for interdisciplinary design. The concept of teaching as design is therefore integral to the investigations in Chapters 6, 7, and 8.

In these latter three chapters, to investigate the situated nature of designing for interdisciplinary teaching and learning, the Activity-Centred Analysis and Design (ACAD) wireframe¹⁴ (Goodyear et al., 2021), an analytical tool for designing, was used as a visual

¹³ Configurations is the term used by Øland et al. (2023) to refer to the ways that interdisciplinarity is manifested in different contexts.

¹⁴ See Chapter 3 for more detail on the ACAD framework (figure 7.1), the ACAD wireframe (figure 3.4) and information on how they were used as a visual heuristic to guide interviews relating to design experiences.

heuristic to guide interview questions. The ACAD wireframe is used to strategically investigate experiences with consideration of the social, physical, and epistemic aspects of approaches to interdisciplinary teaching and learning (Chapter 6), design processes for interdisciplinary teaching and learning (Chapter 7), and the development and sustainability of interdisciplinary courses concerning the institutional environment (Chapter 8). Its use enables an analytical approach to investigate the complexity of design experiences across levels of activity.

2.3 The Approach

Phenomenography is premised upon the idea that people experience phenomena in the world in different ways (Marton, 1986). In phenomenography, there can be multiple ways that a phenomenon can be experienced (plurality) and ways of experiencing are relative to the local setting, including physical, social, and epistemic aspects. Interdisciplinary educational practices have been described as plural and situated (Øland et al., 2023; Vienni Baptista et al., 2020). This makes phenomenography well-suited to studying interdisciplinarity.

The other two conceptions introduced in this chapter identify a spectrum of ways of understanding teaching, learning, and design in higher education. Central to this is how people conceptualise knowledge and design. First, with the three metaphors of learning for interdisciplinary teaching and learning, students may acquire knowledge from different disciplines, and they may also learn by participating in interdisciplinary teams on projects. These two metaphors of learning may experience different knowledge and different perspectives. However, with the knowledge creation metaphor, they are co-creating knowledge, drawing on different disciplinary knowledges, and knowledge practices to create and work with knowledge in novel ways where different approaches, hybrid approaches, or even new approaches are required to address complex or wicked problems.

Similarly, designing for interdisciplinary teaching and learning must account for the use of different strategies, including direct instruction, creating interdisciplinary teamwork experiences, and facilitating, guiding, and co-creating with students in interdisciplinary knowledge co-creation activity. The conception of teaching as design views design as not limited to course creation or lesson planning in advance but requiring flexible ‘on the fly’ adaptation and design work during the enactment of courses, and following courses to revise, adapt, and iterate upon them. It also views design processes themselves as situated, and therefore multiple and adapted to the aims and considerations of the local setting. Simply put, design practices for interdisciplinary teaching and learning can, and should vary. It is characterised by working on novel problems, in novel ways, necessitating that teaching, learning, and design are flexible and fit to purpose. There can be, however, ways of experiencing design for interdisciplinary teaching and learning that range from aligning to less to more awareness, elaboration, and comprehensiveness. These five interrelated concepts form the foundation for the investigation of variation in ways of experiencing design for interdisciplinary teaching and learning.

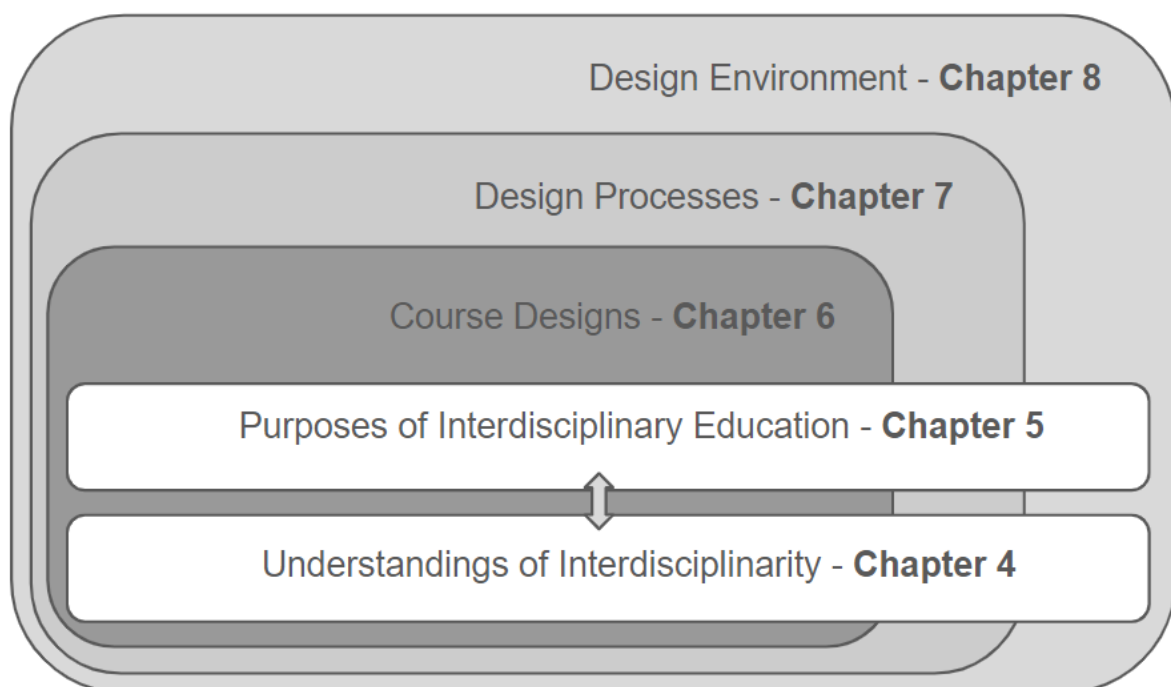
Identifying variation in how a phenomenon is experienced alone contributes little to practitioners in the absence of an awareness of the environment in which it takes place. This thesis identifies and maps out the relationships between different ways of experiencing designing for interdisciplinary teaching and learning for each research question. Additionally, this thesis explores and maps out the relationships between the five different aspects of the study. This is done to explore the part-whole relationships across micro (course design), meso (design process), and macro (design environment) levels using the ACAD wireframe. First, understandings of interdisciplinarity (Chapter 4) and conceptions of the purpose of interdisciplinary education (Chapter 5) underlie the investigations into approaches to interdisciplinary teaching and learning (Chapter 6), experiences of design processes (Chapter

7), and interdisciplinary course development and sustainability concerning the institutional environment (Chapter 8). Course designs (Chapter 6) are a product of course design processes (Chapter 7) which take place in environments for design (Chapter 8). Figure 2.1 illustrates how the five research questions relate to one another. Adaptations of this visual will be used at the introduction to each of the outcomes chapters (Chapters 4–8) to show where that specific aspect of investigation fits into the overall study of experiences of designing for interdisciplinary teaching and learning.

Now that the conceptual background has been established, the following chapter will describe the study’s methodology, the design of the empirical study, and the methods that were used to answer the study’s research questions.

Figure 2.1

A visual representation of the five interrelated areas of inquiry



Chapter 3: Methodology

The purpose of this chapter is to present the study's methodology, research design, and the methods used for empirical investigation to answer the study's five research questions, which are:

1. How do leaders of interdisciplinary courses understand interdisciplinarity?
2. How do interdisciplinary course leaders conceive of the purpose of interdisciplinary education?
3. How do course leaders approach teaching and learning when designing interdisciplinary courses?
4. How do course leaders experience educational design processes when developing interdisciplinary courses?
5. How do course leaders experience their institutional environments when developing and sustaining interdisciplinary courses?

Together, they answer the main research question: *How do course leaders experience designing for interdisciplinary teaching and learning in higher education?*

This chapter first describes phenomenography, the study's methodological approach including its theoretical foundations, its non-dualist ontology and epistemology, justification for its use, the significance of its use, and its output – the phenomenographic outcome space. Then it details the study's research design and methods.

3.1 Phenomenography

Phenomenography is a methodology for conducting research that is used to map “the qualitatively different ways in which people experience, conceptualize, perceive and understand various aspects of, and phenomena in, the world around them” (Marton, 1986, p. 31). Trigwell (2006) describes it as taking “a relational qualitative perspective that aims to describe key aspects of variation in the collective experience of phenomena, rather than

focusing on the individual experience”. (p. 367). Åkerlind (2024) explains the importance of phenomenographic outcomes for teaching and learning, noting that its analytic approach delineates different aspects of how a phenomenon is experienced. It therefore focuses on the range of ways of understanding and experiencing a phenomenon, rather than on the frequency of experiences (Åkerlind, 2008). Its purpose is to support the ‘conceptual expansion’ (Åkerlind, 2024) of a phenomenon and thereby aims to bring awareness of variation, reporting outcomes that advance from less to more comprehensive ways of experiencing the phenomenon (Sandberg, 1997).

In this study, investigating experiences of designing for interdisciplinary teaching and learning (the phenomenon) across a university is important precisely because interdisciplinary educational practices are situated and can differ from one setting to another, even within a university. This study aims to investigate the variance in experiences across a university and to identify and map out the relationships between them. This is in response to calls for a move beyond individual accounts of interdisciplinarity (Graff, 2016; Øland et al., 2023; Vienni Baptista et al., 2020) in the study of interdisciplinary research and education.

The Theoretical Foundations of Phenomenography

Phenomenography espouses a non-dualist ontology and epistemology. Ontologically, it rejects the notion that there is a separation between an objective world that exists external to human experience, and a subjective experience of the world that exists in the mind (Säljö, 1997). Phenomenography therefore investigates the relationship between an objective phenomenon and the subjective experiences of that phenomenon. A phenomenon is therefore understood in relation to the people who experience it (Sin, 2010).

The goal of phenomenography is not to describe a phenomenon, but to characterise how the phenomenon appears to a group¹⁵ of people (Marton, 1986). Phenomenography is theoretically underpinned by a second-order perspective (Han & Ellis, 2019). Whereas a first-order perspective places emphasis on investigating a phenomenon *through* people's experiences (Åkerlind, 2018) and usually involves direct observation, a second-order perspective involves reflection on experiences and investigates *how* a phenomenon is experienced, and the collective meaning attributed to the experiences (Han & Ellis, 2019).

Phenomenography acknowledges that it is possible for the world to be experienced in different ways and is concerned with expanding people's awareness of the different ways of experiencing a phenomenon. It makes no claims about what is 'true' about a phenomenon, instead, phenomenographic research aims to generate and present an outcome space that is 'useful' (Orgill, 2012). Whereas some understandings, conceptions, and experiences may be less developed or comprehensive than others, they are not considered to be 'incorrect'. For example, participants may understand interdisciplinarity through a concrete textbook definition, and/or they may also construct their own understandings. This aligns with a pluralist perspective in which multiple existing experiences of a phenomenon can exist, not just one 'correct' way of experiencing a phenomenon.

Epistemologically, at its core phenomenography is relational (Bowden & Green, 2005; Bowden & Walsh, 2000). It is the relationship between a phenomenon and participants' understandings, conceptions, and experiences of that phenomenon that is important (Marton, 1986). Additionally, a phenomenographic approach is based on the relationship between the researcher and the data, a relationship that is not entirely objective or subjective. Researchers' backgrounds are important because outcomes are generated

¹⁵ In this thesis, the group of people refers to interdisciplinary course leaders from different disciplinary backgrounds that are representative of the breadth of faculties and disciplinary structures at the university.

through a relationship between the researcher and the data; researchers do not simply identify outcomes that exist out in the world. However, researchers should be careful not to guide the generation of outcomes to fit their preconceptions. Methods to manage bias will be discussed later in this chapter.

Justification for the Use of Phenomenography

Phenomenography has a long history in educational research and is “an empirical research tradition that was designed to answer questions about teaching and learning, particularly in the context of educational research” (Orgill, 2012, p. 2608). Phenomenography is well-suited for this study of teaching and learning because its purpose is to study variation across a group of participants, and it is well-suited to studying complexity because it is both explorative and analytical (Barnard et al., 1999). It can support the development of an understanding of how a group of individuals make sense of a shared phenomenon. In this study, phenomenography is well suited to support the development of a deep understanding of how course leaders (the group of individuals), experience design for interdisciplinary teaching and learning (the shared phenomenon).

Phenomenography was chosen over other candidate qualitative methodological approaches including ethnography, discourse analysis, and grounded theory for a number of reasons.

To begin, phenomenography enables structured analysis of data that can provide a systematic way of categorising and mapping course leaders’ experiences, presented in a logically structured outcome space (Åkerlind, 2005). This enables investigation of patterns and relationships in a complex phenomenon characterised by diversity in practice. This contrasts with methods which are better suited to in-depth analysis rather than identifying

patterns across a phenomenon marked by variation such as ethnography (Neuman, 2014) and critical discourse analysis (Gournelos et al., 2019).

Additionally, phenomenography begins with a clear focus of inquiry prior to data collection, making it even further suited to investigating complex practices. In comparison, grounded theory is predicated upon discovery with limited initial focus identified (Birks & Mills, 2010), making the investigation of complex phenomenon challenging, especially in relation to the phenomenon of designing interdisciplinary teaching and learning, a phenomenon which is characterised by variation and complexity (Vienni Baptista et al., 2020).

Phenomenography also requires limited resources and time to conduct research. In comparison, ethnographic methods employ thick description which may require significant time and resources (Neuman, 2014), and grounded theory approaches may require multiple interviews with individual participants (Charmaz, 2001) and can include multiple forms of data collection including interviews, focus groups, fieldnotes, memoing, and materials and non-traditional data sources (Birks & Mills, 2010). These factors make a phenomenographic approach to studying a phenomenon within a whole university environment manageable for a thesis.

However, phenomenography has limitations in comparison with other qualitative methods. It does not capture the richness of data that ethnographic methods are capable of capturing (Neuman, 2014). Additionally, critical discourse analysis may be useful for understanding the context that an event happens within (Gournelos et al., 2019). Further, grounded theory approaches aim to develop theory that explains a phenomenon of interest whereas phenomenography explores and describes (Birks & Mills, 2010). However, the aim of this thesis is to bring greater awareness to the qualitatively different ways that course

leaders experience designing for interdisciplinary teaching and learning at a university, and to explore the relationships between them.

Additionally, in this thesis, the ACAD wireframe (Goodyear et al., 2021) was used as a heuristic in interviews to navigate the social, set, and epistemic aspects of the phenomenon across micro, meso, and macro levels, thereby enabling greater investigation of the local circumstances in course leaders' institutional environments. Its use aims to generate an outcome space that is useful to practitioners (Orgill, 2012). Phenomenography generates useful knowledge that can help course leaders and university leadership develop a greater awareness of ways of experiencing designing for interdisciplinary teaching and learning and help them navigate the variation and complexity they face.

Interdisciplinary teaching and learning practices in higher education are increasingly understood as multiple and situated in the literature, including systematic reviews and studies of multiple cases (Øland et al., 2023; Vienni Baptista et al., 2020). There is both an acceptance and encouragement of variation, in contrast with the tendency in individual case studies to 'other' and 'universalise' interdisciplinarity, converging meanings and practices (Lindvig & Ulriksen, 2019). Prior research in interdisciplinary education has called for research that investigates variation, including the need to investigate different understandings of interdisciplinarity (Vienni Baptista et al., 2020); the diversity of purposes in educational practices within universities (Lyll et al., 2016); and the different forms that interdisciplinary education takes, and why those forms are taken (Øland et al., 2023). This thesis aims to add to these prior studies and contribute empirical outcomes on the variation in how course leaders experience designing for interdisciplinary teaching and learning and the relationships between different ways of experiencing this phenomenon by examining variation across a shared setting in line with phenomenographic conventions.

3.2 The Phenomenographic Outcome Space

Phenomenographic research aims to produce an outcome space that presents a logical structure between a study's outcomes. The outcome space is composed of two components: the referential and the structural component. First, the referential component is comprised of the categories of description and relates to the 'what' of the outcomes. Second, the structural component is comprised of the dimensions of variation and relates to the 'how' of the outcomes (Åkerlind, 2005). In a phenomenographic outcome space, the categories are organised hierarchically, advancing from showing less to more awareness of the phenomenon. Åkerlind (2024) describes an outcome space as "one of inclusivity, in the sense that understandings higher in the hierarchy have been placed there because they include awareness of understandings lower in the hierarchy, but not vice versa" (p. 6). In this thesis, categories have been described as increasing from less to more comprehensiveness (Sandberg, 1997).

An outcome space's dimensions of variation offer a means to explore and map out the relationships between categories, including differences and similarities. This is what separates phenomenographic outcomes from findings using thematic analysis; an outcome space focuses on exhibiting the relationships between categories, not just creating taxonomies. Together, the categories of description and the dimensions of variation form a *space* of outcomes that emphasises the relational nature of how a phenomenon is experienced.

It is important to note that for this study, although there was only a single set of interviews, they aimed to answer the study's five research questions, and in doing so, to create five outcome spaces, each of which focused on a different aspect of design for interdisciplinary teaching and learning reported in Chapters 4, 5, 6, 7, and 8. Investigating the relationships between the five outcome spaces generates further insights into the relationships

between understandings, conceptions of purpose, and different ways of experiencing designing for interdisciplinary teaching and learning. The relationships between these outcome spaces are explored in Chapter 9.

3.3 Research Design

Setting

The study was conducted at the University of Sydney, a comprehensive¹⁶ research-intensive Australian university with a 150-year history. The university is structured into faculties and schools according to disciplines. There are also six multidisciplinary research centres at the university, however, the research centres do not offer their courses or degree programmes. Several of this study's participants were also members of multidisciplinary research centres in addition to being members of faculties.

Interdisciplinary undergraduate courses include courses from a shared pool at the university that allow students to study electives, together with students from diverse disciplinary backgrounds. Courses were developed in and across different faculties and disciplines to support students' work on complex, real-world issues. These courses are characterised by variation in what discipline or faculty hosts them, how they are funded, what students can enrol, and how they are developed and sustained.

This section describes the research design in detail. Much of this chapter is repeated with less detail in each of the methodology sections in the five articles (Chapters 4–8). Familiarity with this section prepares a reader so they do not need to reread the methodology sections of Chapters 4–8 in detail.

¹⁶ A comprehensive university is one that offers degree programmes from a wide range of disciplines, centres on both research and teaching, and receives government funding.

Sampling

This study used a purposeful sampling approach with a maximum variation strategy common to phenomenographic studies (Bowden & Green, 2005; Limbu & Markauskaite, 2015; Marton & Booth, 2013). The aim of the purposeful sampling approach used was to identify participants at the university with experience in leading or contributing substantially to the conceptualisation, design, redesign, or enactment of interdisciplinary courses. This purposeful sampling approach had two steps: (1) identifying interdisciplinary courses, and (2) identifying course leaders who were associated with the identified pool of courses. To restate, this thesis explores course leaders' experiences of designing and does not directly investigate course designs or design processes.

The first step in the sampling process was therefore to identify interdisciplinary courses at the university. A set of criteria was created to evaluate the 'interdisciplinarity' of a course. The criterion included: (1) the course title or description identified the course as *multidisciplinary*, *interdisciplinary*, or *transdisciplinary*, (2) student groups for teamwork were described as being interdisciplinary in constitution, (3) the course outline included a project-based learning component, (4) the course described its focus as being on *real-world* problems, (5) the course described itself as being focused on *complex* or *wicked* problems, and (6) the course described student activity as conducting research or creating new knowledge. Course outlines from the university's website were used to review the courses against each of the study's criteria. To classify a course as interdisciplinary, the course must have included both criteria 1, 2, and 3 and could also have included any or all of criteria 4 to 6. The sample pool included 80 courses.

Once the sample pool was established, the next step was to identify academics who contributed substantially to the creation, design, redesign, or enactment of interdisciplinary courses. A set of criteria were developed to identify suitable participants for the study. The

purposeful sampling criterion for participants included: (1) they were academics/teachers at the university in 2020 or 2021, and they were either (2) coordinators of courses that were identified as being interdisciplinary, or (3) were identified as being significantly involved (alone or in teams) in creating, developing, designing, redesigning, enacting, or adapting the course. Academics associated with courses in the sample pool were contacted via email and asked about their role in the course to identify if they fit these criteria, and if they would be interested in participating in the study.

Following these two steps, a maximum variation strategy was used to ensure the study had disciplinary representation from across the university's faculties and disciplinary structures. A maximum variation strategy is also common to phenomenographic research, specifically for generating a sample with a wide range of variation across key indicators such as age, gender, experience, and discipline (Bowden & Green, 2005).

Academics were contacted in three intermittent requests to participate in the study. Following the third set of invitations to participate, a total of 59 potential participants had been contacted, of which 36 responded and a total of 23 had been interviewed. The analysis of the data from the interviews was done in parallel with conducting further interviews. After conducting 23 interviews it was observed that no new understandings were forthcoming. It was decided that sufficient data had been gathered as data saturation had been reached. Although there are no standard sample sizes for phenomenographic research in higher education, prior studies offer insights into manageable and suitable sample sizes. Markauskaite and Wardak (2015) recommend a sample size of 15 to 30 participants in higher education research. Trigwell (2000) advises that more than 20 participants risk the generation of too much data for a phenomenographic researcher to effectively analyse as a whole. Trigwell (2006) acknowledges that up to 30 participants are possible but notes that so many participants necessitate a substantial research undertaking. Bowden and Green (2005) also

argue that to ensure sufficient variation and to maintain a manageable amount of data, anywhere between 20–30 participants is an ideal sample size. In addition to having reached data saturation, this study's sample falls within the recommended parameters.

Participants

The participants represented equitable distribution among academics, with twelve at lecturer-level positions (Lecturer or Senior Lecturer), and eleven at professorial-level positions (Associate Professor or Professor), 12 female participants, and 11 male participants. Additionally, as shown in Figure 3.1, the sample was representative of a variety of disciplinary fields, including business and law (4), the sciences (4), the arts, humanities, and social sciences (5), engineering and design (4), and medicine and health (6). In Figure 3.2, participants are shown to average 14 years of academic experience, of which an average of 3.5 of those years included experiences as interdisciplinary course leaders. Therefore, 25% of their total years of academic experience included experiences of designing for interdisciplinary teaching and learning.

Data Collection

Semi-structured phenomenographic interviews, standard in phenomenographic research (Åkerlind, 2018), were conducted via videoconferencing. Interviews lasted between 40 and 70 minutes, in line with interview duration to enable the exploration of experiences in depth (Trigwell, 2006). Participant information statements and consent forms were emailed to potential participants when invited to participate in the study and were collected in advance of the arranged interviews. Information on both can be found in Appendices A and B respectively.

Figure 3.1

Participants' disciplinary backgrounds

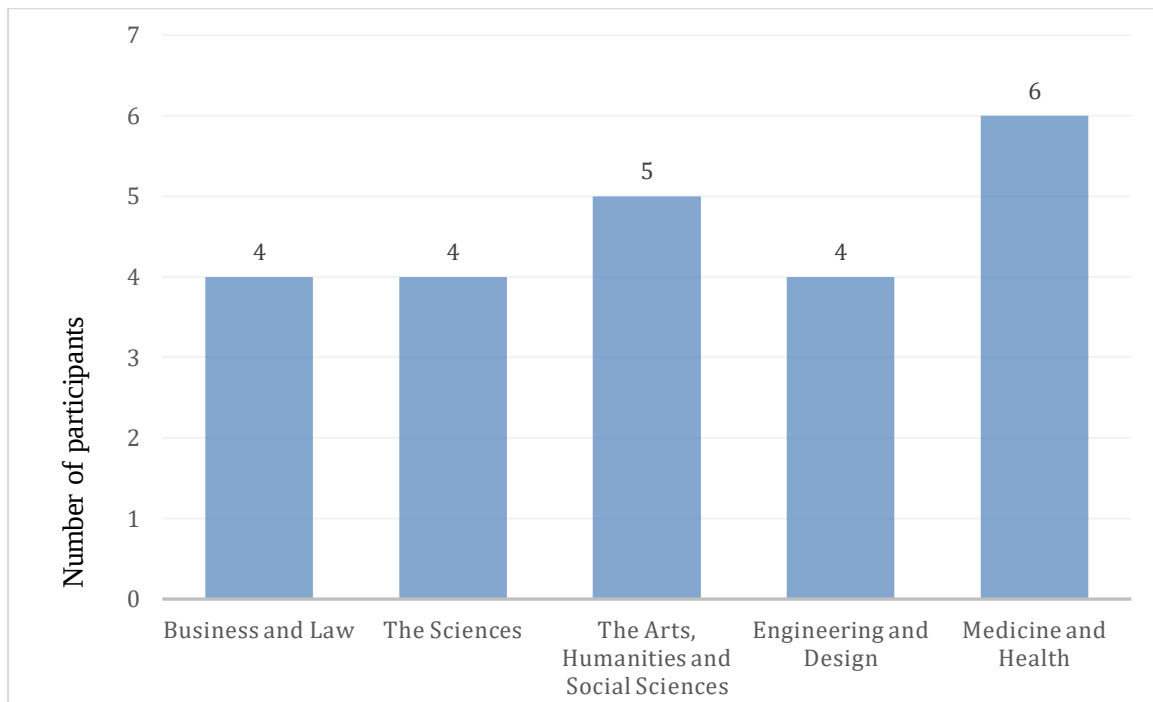
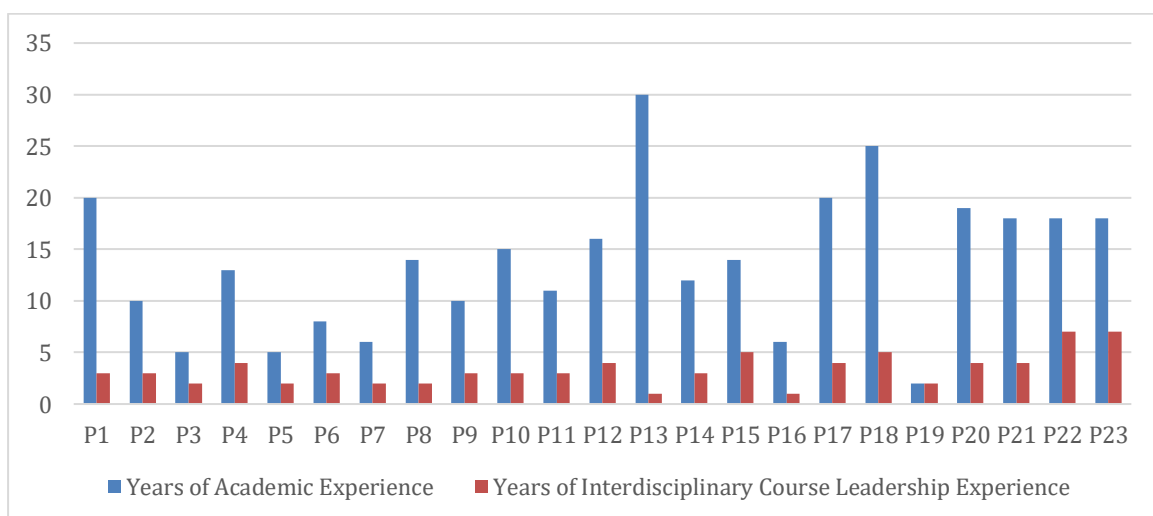


Figure 3.2

Participants' years of experience in academia and leading interdisciplinary courses



The following protocol was used for the interviews:

1. **Review participant background:** Review profile pages (e.g., university website, Google Scholar, and LinkedIn) as well as associated interdisciplinary course outlines before the interview to ensure familiarity with the participant's field of research, disciplinary expertise, and course.
2. **Remind the participant of the focus of the study:** Ask if they have any questions about the project.
3. **Ensure consent has been provided:** Check the participant has signed the participant consent form. Ask them for verbal consent and ask them to fill out the participant consent form if they have not already done so.
4. **Remind participants about confidentiality:** Remind participants that they can request to exclude any particular statements if they are confidential, or if they do not want them used.

During the interviews, prompting questions were asked, including requests for further information and elaboration or explanation of details provided (Bowden & Green, 2005). Interviews employed a theoretically-informed heuristic, the Activity-centred Analysis and Design (ACAD) wireframe (Goodyear et al., 2021) as a visual scaffold for use with exploring interview questions 3, 4, and 5 to cover the wide variance in potential experiences of designing for interdisciplinary teaching and learning across the set, epistemic, and social aspects of course leaders' design experiences, across macro, meso, and micro levels. The Interview Schedule can be found in Appendix C. This wireframe enables the strategic investigation of experiences holistically across a research setting, opening up exploration of experiences to the physical, social, and epistemic across multiple levels of focus in the institutional environment. As reported in the literature review (Section 2.2), the existing literature largely reports studies that focus on individual aspects, or the syntheses of findings

from individual studies, often finding that course leaders' experiences of design are diverse and situated. This, due to a lack of shared research setting, limits the investigation of the relationships between different ways of experiencing designing for interdisciplinary teaching and learning. In this research, the investigation of a broad range of interdisciplinary course leaders' experiences related to designing for interdisciplinary teaching and learning in the same institutional environment, using the same methodology and participants, enables the generation of novel insights when investigating the relationships between diverse, situated experiences.

The ACAD wireframe (Figure 3.3) was used as a visual scaffold to prompt further participant description of experiences concerning the social, set, and epistemic design aspects of participants' experiences across micro-, meso-, and macro-levels of the university. For example, if a course leader talked about using a specific room for collaborative design work (Meso level), they would be asked about what tools and other material items they used in the room to support design activities (the micro level) and whether or not the digital and physical infrastructure in the room was developed specifically for design work (the macro level).

Figure 3.3

The ACAD wireframe (Adapted from Goodyear et al., 2021)

	Set Design	Epistemic Design	Social Design
Macro level	<i>Buildings & technology</i>	<i>Stakeholder values</i>	<i>Organisational structures</i>
	Physical and digital infrastructure	Forms of knowledge production & sharing	Structures in use: hierarchal, networked...
Meso level	<i>Allocation/use of Spaces & technology</i>	<i>Curriculum</i>	<i>Community</i>
	Availability, access, and choice	Activities, courses, programmes, degrees	Interdisciplinary, Disciplines, industry...
Micro level	<i>Artifacts, tools & resources</i>	<i>Selection, sequence & pace</i>	<i>Divisions of labour & roles</i>
	Tools, tech devices, whiteboards...	Content, sequencing, task types	Facilitation, group structures, scripts...

The ACAD wireframe helps as a visual scaffold to explicitly consider the relationship between theoretical concepts and the enactment of a design across scale levels when designing (Goodyear et al., 2021). The single overview of the wireframe helps “researchers break down the complexity of designs, visualize part-whole relationships and, in tracing degrees of correspondence between dimensions of design—left to right, and scale levels—top to bottom” (Carvalho & Yeoman, 2021, p. 35). The ACAD wireframe was used to establish consistency in the interview process itself, enabling an unvaried process to explore the wide variance in design experiences.

Data collection involved only interviews due to both methodological and practical reasons. First, methodologically, phenomenography does not directly study a phenomenon—it studies how participants experience a phenomenon - a second order, not a first order form of investigation (Åkerlind, 2018). It focuses on gathering participants’ accounts of their experiences of a phenomenon, using phenomenographic interviews as the common method of data collection. Directly studying the practices and processes of design (design praxeology) is less common in phenomenographic investigation. Second, practically, the study was conducted during Covid-19 lockdowns when participants were working from home. Therefore, the direct study of design for interdisciplinary teaching and learning was not possible. In addition, at that time, educational design work was directed towards transitioning to a remote learning approach and was different from ‘normal’ design practices.

Data Analysis

As initial analysis was conducted concurrently with ongoing interviewing, interview recordings were transcribed verbatim after each interview. Next, I reviewed the transcript and identified data relevant to answering the research question from the entire transcript.

Although participant responses to specific interview questions comprised the majority of the data relating to each particular research question, the entire transcript was reviewed and used

to answer each of the research questions. For example, if a statement in an interview aligned with an understanding of interdisciplinarity in response to a question that was not directly asking a participant about their understanding of interdisciplinarity, it was still used to answer that specific research question about understandings of interdisciplinarity.

Analysis was guided by Åkerlind's (2012) iterative process which involves sorting data and comparing them with and against other similar quotes, with consideration of how they relate to the categories of description being constructed. I coded transcripts by semantic meaning into preliminary codes and then grouped the preliminary codes by semantic similarity into initial categories. Next, I constructed tables with quotes exemplifying key meanings in each code and category. To enhance trustworthiness (Åkerlind, 2005), the primary supervisor critically reviewed the analysis.

The following steps were undertaken in collaboration with the primary supervisor and included: (1) comparing and contrasting initial codes and categories using shared tables and refinement into categories; (2) reviewing the categories against the entire corpus of data to ensure no relevant data was missing and the included quotes were correctly interpreted; (3) identification of dimensions of variation to make differences and relationships between the categories more explicit; and (4) final review of the resulting categories and dimensions, and the quotes that support them to create a coherent and justifiable outcome space. The outcome space was then reviewed by my supervisors.

The analysis was non-linear. The process was characteristic of what Åkerlind (2012) describes as "a strongly iterative and comparative one, involving the continual sorting and resorting of data, plus ongoing comparisons between the data and the developing categories of description, as well as between the categories themselves" (p. 118). This involved sorting and resorting of data within each study and sorting and resorting data across studies as well. The was repeated for each of the five articles (Chapters 4, 5, 6, 7, and 8).

Methodological Limitations and Trustworthiness

Trigwell (2006) describes phenomenography as a research approach that “aims to describe the key aspects of the variation of the collective experience of a phenomenon rather than the richness of individual experiences” (pp. 368–369). Phenomenography therefore does not generate outcomes related to the frequency of ways of experiencing a phenomenon. It simply describes the variation in collective experiences of a phenomenon and the relationships between them. By describing the variation in collective experiences, the outcome space can help to raise people’s awareness of the qualitatively different ways that designing for interdisciplinary teaching and learning is experienced.

Phenomenography can be done in different ways, by people with varying levels of expertise in conducting phenomenographic research. The quality of phenomenographic research can be identified by its defensibility (Åkerlind, 2012) which is based on the transparency of its methods, and whenever possible having experienced and informed phenomenographic researchers involved in the research.

Additionally, phenomenography does not report on practice but instead generates an outcome space based on the relationship between the researcher and the data collected from semi-structured interviews. Outcome spaces are generated through that relationship. This means that the same data set could be used to generate different outcomes if used by different researchers (Ashwin, 2023). If this is not understood, outcomes could be seen as being biased. Åkerlind (2024), however, views bias as researchers’ interpretive subjectivity, meaning that bias is possible, but it relates to the lens within which researchers generate outcomes. She addresses critiques of phenomenographic researcher bias by laying out the methodological strategies in place to limit this. Bias therefore is not inherent to phenomenography although it may be a limitation only if there are no strategies in place to address interpretive subjectivity.

In quantitative research, notions of validity and reliability are used to ensure rigorous scientific conduct, but in qualitative research, they have been overtaken by the notion of trustworthiness (Sin, 2010) whereas Åkerlind (2005) describes validity and reliability in phenomenography as generating both trustworthiness and credibility. First, she lays out two types of *reliability* checks researchers can employ during analysis, including (1) *coder reliability checks* where two or more researchers code samples (or all) interview transcripts and compare categorisations, and (2) *dialogic reliability checks* where researchers reach an agreement on the interpretative hypotheses through discussion and mutual critique. Second, she lays out two types of *validity* checks phenomenographic researchers can employ, including (1) *communicative validity checks* that involve ensuring the research results are defensible to not only the researcher but to the research community and intended audience as well, and (2) *pragmatic validity checks* that involve judging the extent to which a study's outcomes are useful and meaningful to their intended audience.

For this study, data analysis in all five of the chapters drew on phenomenographic approaches and techniques (Åkerlind, 2012; Marton, 1986). To develop the categories of description and dimensions of variation, Åkerlind's (2012) iterative approach of sorting data and contrasting it with and against other comparable quotes served as the basis for analysis. Following the transcription of interview recordings and initial coding to identify key themes and the classification of quotes by semantic meaning, the primary supervisor conducted *coder reliability checks* (Åkerlind, 2005) by reviewing and advising on the coding process. Both transcripts and NVivo coding were reviewed using shared screen mode during videoconferencing supervisory sessions to ensure that not only were the processes for coding appropriate, but the coding itself was justifiable. Whereas coder reliability checks are described as asynchronous followed by discussion and critique (Åkerlind, 2012), the approach taken was one of expert mentorship in conducting phenomenographic coding which

Åkerlind (2024) argues ensures the quality of phenomenographic methods. Additionally, ongoing *dialogic reliability checks* (Åkerlind, 2005) were conducted on not only the coding but also the creation of categories of description and dimensions of variation throughout the construction of the five research articles that together constitute this thesis.

Validity checks were also employed. During the analysis process, the categories of description and dimensions of variation were refined and renamed based on the critical feedback of the primary and secondary supervisors. Additionally, journal reviewers' feedback acted as a *communicative reliability check* (Åkerlind, 2005), highlighting weaknesses in the defensibility of the outcome space, and prompting its iterative improvement.

A researcher's interpretive processes during qualitative analysis can never be entirely objective (Åkerlind, 2005). Rigorous phenomenographic analysis therefore must take measures to address potential subjectivity. In this study, the analysis process was highly iterative and at stages involved the PhD candidate together with two supervisors with substantial expertise conducting phenomenographic analysis. The mentorship, collaboration, and feedback on analysis contributed to increased trustworthiness of the outcomes.

Lastly, the study was designed, and the subsequent interview schedule was constructed to investigate five aspects of the experience of designing for interdisciplinary teaching and learning to enable a holistic account of the variation in course leaders' experiences. It used a data set deliberately collected for multiple investigations. Reusing the same data in multiple studies can be sometimes problematic. For example, it is often referred to as 'salami slicing' wherein data is broken up into smaller units to facilitate more publications (Ding et al., 2020). Methodologically, dividing the data set into smaller parts risks decontextualising the data, which can lead to oversimplification, and it is a practice that is considered to be unethical which diminishes the quality of published research (Pongrácz & Camerlink, 2022). To address these issues, the interview schedule was deliberately

constructed to investigate different but interrelated aspects of the experience. Multiple analyses were not aimed to generate a greater number of publications, but to enable depth and breadth of investigation simultaneously by focussing on answering interrelated research questions and producing an integrated account of the course leaders' experiences. To mitigate the risks of using the same dataset for five different analyses, the subset of data used in the analysis for any research question was identified in advance and, beyond the shared contextual information, not reused in any other research question. This thesis synthesises the outcomes from the five different areas of investigation.

Ethics

The research was conducted in accordance with the University of Sydney's Human Research Ethics Committee-approved ethics protocol (approval #2020/668). Further information can be found in Appendix D.

Chapter 4: A Phenomenographic Exploration of Course Leaders' Understandings of Interdisciplinarity

This chapter is an article published by Taylor & Francis in Studies in Higher Education.¹⁷

Ripley, D., Markauskaite, L., & Goodyear, P. (2024). A phenomenographic exploration of course leaders' understandings of interdisciplinarity. *Studies in Higher Education*, 49(11), 2208–2221. <https://doi.org/10.1080/03075079.2023.2293932>

The meaning of interdisciplinarity has been the subject of decades of scholarly debate and understandings can vary widely. There have been calls for research to investigate its multiple meanings and practices (Graff, 2016; Nersessian, 2019). To understand course leaders' experiences of designing for interdisciplinary teaching and learning (Chapters 6, 7, and 8), it is imperative to first establish the ways they understand interdisciplinarity (Chapter 4) and the ways they conceive of its purpose (Chapter 5). See Figure 2.1 to view how the chapters are interrelated.

For this article, I conducted data collection, data analysis, and the original draft preparation and revisions based on feedback from both supervisors and from two anonymous peer reviewers. Lina Markauskaite was responsible for reviewing and editing multiple drafts of the paper, and conducting data analysis, and Peter Goodyear was responsible for reviewing and editing drafts. My contribution to the paper is estimated at 75% and my supervisors at 25%.

¹⁷ This article was published first, earlier on in the PhD candidature, so some language used in it may differ from the following four articles.

A phenomenographic exploration of course leaders' understandings of interdisciplinarity

Dwayne Ripley , Lina Markauskaite  and Peter Goodyear 

Sydney School of Education and Social Work, The University of Sydney, Camperdown, Australia

ABSTRACT

The number of interdisciplinary courses being developed in higher education across different countries is increasing. The people responsible for developing and enacting interdisciplinary courses can have significant design and teaching autonomy, but little is known about how they understand interdisciplinarity. This study uses phenomenographic interviews to address the question: how do interdisciplinary course leaders understand interdisciplinarity? This includes exploration of the relationships between different understandings of interdisciplinarity.

Findings from interviews with 23 interdisciplinary course leaders reveal understandings of interdisciplinarity expressed in relation to (A) definitions, (B) knowledge spaces, and (C) situated knowledge work practices. Understandings were multiple and heterogeneous; they varied between participants and more importantly participants each expressed understandings belonging to multiple categories. Findings show that academics' views about what interdisciplinarity means are rarely exclusively aligned with normative definitions, but instead are marked by individuals' construction of meaning through processes of acquisition, sense-making and situational judgment.

The study's findings could be used in future educational design and planning work to elicit and discuss different stakeholder understandings of interdisciplinarity.

ARTICLE HISTORY

Received 23 August 2023

Accepted 7 December 2023

KEYWORDS

Understandings of interdisciplinary;
interdisciplinary teaching;
higher education; academic leaders; phenomenography

Introduction

Universities in many countries have significantly expanded their interdisciplinary curricula over the past decade (Lindvig, Lyall, and Meagher 2019; Lyall et al. 2015). In a world marked by rapid technological change, post-truth politics, and systemic wicked problems, universities aim to strengthen students' capacities for engaging with complexity and uncertainty through interdisciplinary courses. However, interdisciplinary courses are often developed at the fringes of universities and their academic departments, left to the discretion of individual academics or small teams (Lindvig, Lyall, and Meagher 2019). This results in significant diversity in course goals, curriculum designs, and student outcomes (Lyall et al. 2015). Little has been documented about how interdisciplinarity is understood by academics with significant agency over the creation and enactment of interdisciplinary curricula at universities.

CONTACT Dwayne Ripley  dwayne.ripley@sydney.edu.au  Sydney School of Education and Social Work, The University of Sydney, Building A35, Camperdown, NSW 2006, Australia

© 2023 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group
This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivatives License (<http://creativecommons.org/licenses/by-nc-nd/4.0/>), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited, and is not altered, transformed, or built upon in any way. The terms on which this article has been published allow the posting of the Accepted Manuscript in a repository by the author(s) or with their consent.

Debates on the meaning of interdisciplinarity and the terminology are numerous and longstanding. It is commonplace for scholars in the area to problematise 'interdisciplinarity' and critique different understandings (Barry, Born, and Weszkalnys 2008; Klein 2017) or misunderstandings (Nowotny 2019), so much so that it has been characterised as 'among the most talked about but most misunderstood topics in education on all levels' (Graff 2016, 775). Subsequently, there are calls for empirical research that moves beyond assumptions and critique of definitions to investigate how interdisciplinarity is understood by those who engage in interdisciplinary work (Albert, Vuolanto, and Laberge 2023; Nersessian 2019; Nowotny 2019), including how different understandings relate to specific interdisciplinary practices and contexts (Franks et al. 2007; Lindvig, Lyall, and Meagher 2019; Vienni Baptista et al. 2020).

It is not uncommon for innovations in education to develop in the absence of rigorous empirical evidence (Goodyear 2018). However, the scarcity of empirical research on practices and on understandings of interdisciplinarity in practice pose serious risks to the sustainability of interdisciplinary education. The push for more interdisciplinary programs and courses creates a demand for teachers to understand how to design, teach, and assess interdisciplinary learning (DeZure 2017), yet most of the 'how-to' literature on practices of interdisciplinary education largely exists outside of peer-reviewed journals (Lindvig and Ulriksen 2019). This does not constitute an adequate empirical knowledge base to inform interdisciplinary course development. Together these factors pose a serious problem for the systematic development of interdisciplinary courses.

This study investigates the question, 'How do leaders of interdisciplinary courses understand interdisciplinarity?'. It further maps out how different understandings of interdisciplinarity relate to each other. To accomplish this, it draws on phenomenographic interviews of 23 interdisciplinary course leaders from across the breadth of structures and disciplinary fields at the University of Sydney, an Australian comprehensive research-intensive higher education institution.

To situate our study, we first review some challenges faced in understanding interdisciplinarity and a review of literature related to different approaches to defining interdisciplinarity. We then review some different research settings of investigations into understandings of interdisciplinarity and contextual variance, finishing by noting limitations and identifying calls for future research.

Literature review

Challenges in understanding interdisciplinarity

Despite the term 'interdisciplinary' being used in literature for more than a century (Sills 1986/2016), little clarity has emerged regarding how it is defined. Lindvig and Hillersdal (2019, 23) characterize interdisciplinary literature as 'ripe with definitions, taxonomies, discussions and other attempts to define the concept'. Graff (2016, 781) describes this diversity of language as 'a daunting semantic storm'. He later criticises the conflation of multiple related but distinct concepts including, but not limited to, integration, interaction, intersection, inter-professionalism, team science, multidisciplinary, and transdisciplinarity (Graff 2021) to describe a field which already includes varied concepts such as anti-disciplinarity (Pickering 2013) and systems (Ison 2017).

Offering an alternative perspective, Klein (2017) argues that this diversity of language denotes plurality rather than discord, encompassing both continuity and change in the evolution of its meaning as the term is challenged and extended. However, the mutability of the term 'interdisciplinary' poses a challenge for interdisciplinary teachers who often have limited interdisciplinary experience (Lyall et al. 2015) and must navigate this diversity of language.

Approaches to understanding interdisciplinarity

There are different approaches to articulating the meaning of interdisciplinarity. Some scholars suggest adopting inclusive and encompassing definitions. For example, Barry, Born, and Weszkalnys

(2008) view interdisciplinarity as a wide spectrum, ranging from mere cooperation to invention in interdisciplinary practice and the recasting of disciplines themselves. However, inclusivity and vagueness of terms do not always help in the advancement of knowledge and teaching when specificity matters (Markauskaite 2020). For example, Lindvig and Ulriksen (2019) found that teachers often lump diverse practices together under the umbrella term 'interdisciplinary', *universalising* interdisciplinarity which risks trading off rich context from findings in exchange for purposes of generalisation.

Social and spatial metaphors which focus on interactions are another often-used approach to describing interdisciplinarity (Downey et al. 2019). Integration is one and involves the synthesis or combination of knowledge and methods from different disciplines to achieve an outcome unlikely to be achieved by any single disciplinary approach (Boix Mansilla, Miller, and Gartner 2000; Klein 1990). This is often used in studies of interdisciplinary education in universities (DeZure 2017; Kidron and Kali 2015). However, integration is complex, and Boon, van Baalen, and Groenier (2019) argue that there is a risk of oversimplifying the processes of integrating and combining knowledge from different disciplines, thereby ignoring the epistemic challenges inherent in interdisciplinary knowledge work.

Yet another approach to articulating the meaning of interdisciplinarity employs taxonomies and typologies to compare 'interdisciplinary' with other similar but distinct terms. The terms 'multidisciplinarity', 'interdisciplinarity', and 'transdisciplinarity' have been described as 'sophisticated categorizations of the different forms of disciplinary exchange' (Nikitina 2005, 395). These terms differentiate who is involved, how they interact, and what those involved aspire to achieve in exchanges between disciplines (Repko, Szostak, and Buchberger 2017). However, the assumption that disciplines are well-defined and static has been challenged (Albert, Vuolanto, and Laberge 2023; Brew 2008; Pinch 1990), weakening the efficacy of such comparisons intended to clarify understanding. Nersessian (2019) thus suggests that after decades of discussion of taxonomies, there should be a refocusing of attention onto research that provides precise and authentic accounts of the actualities of interdisciplinary research and education.

Varied contexts, varied understandings

Lindvig and Ulriksen (2019) show that understandings of interdisciplinary are situated within and therefore distinct to local practices. Franks et al. (2007) found conceptions of interdisciplinarity held by leaders of interdisciplinary reforms differed from those of interdisciplinary practitioners, while Lattuca (2003) reported differences between those who research and teach interdisciplinarity, and those who are directly involved in interdisciplinary scholarship. Additionally, Cooke et al. (2020) reported diverse meanings given to interdisciplinarity among members of the College of the Royal Society of Canada, attributing the diversity to individual variances in experiences, values, cultural norms, and values. On a wider scale, in a study of how interdisciplinarity is understood by researchers across Europe, Vienni Baptista et al. (2020, 18) found multiple, heterogeneous, and plural understandings of interdisciplinary terminology, noting 'divergence, nuance, and contextual specificity with differences evident across disciplines, regions, and scholarly communities'.

In relation to institutional practices, Lindvig and Hillersdal (2019) argue that when the institutional framing of interdisciplinarity is unclear it is reflected in a lack of clarity in ground-level practices. To address this, Franks et al. (2007) call for mutually supportive or co-constructed institutional meanings and practices in universities. In relation to research on interdisciplinary understandings, Vienni Baptista et al. (2020) call for studies which not only map different understandings of interdisciplinarity, but also the relationships between them to identify and improve support for interdisciplinarity in universities. We address these multiple calls by investigating and mapping out the variance in understandings of interdisciplinarity among course leaders with varied levels of interdisciplinary experience and positions within a university. We further provide a visualisation in the form of an outcome space that can support the development of institutional understandings of interdisciplinarity and thereby support interdisciplinary teaching and learning at universities.

Methodology

This study aims to investigate and map out the understandings of interdisciplinarity of leaders of interdisciplinary courses. The primary research question is: *How do leaders of interdisciplinary courses understand interdisciplinarity?*

The study employs a phenomenographic approach which enables in-depth investigation of the scope and structure of how different individuals as part of a group understand a phenomenon. The phenomenographic approach is particularly suited to addressing this research question as it enables investigation of the relationships between the categories constructed, whereas systematic literature reviews and the syntheses of case studies are limited to reporting on variance. Also, it permits the study of a larger research sample than is usually feasible with ethnographic approaches.

Phenomenographic research produces an outcome space with two components (Åkerlind 2005). The first contains the *categories of description* which describe *what* participants focussed upon when they described interdisciplinarity. This is called the *referential* component. Second, the *dimensions of variation* show *how* participants' understandings of interdisciplinarity varied across the categories. This is called the *structural* component. The final outcome is a two-dimensional space (referential and structural) that shows how different meanings of interdisciplinarity are interrelated.

Context and sampling

This study was conducted in a comprehensive research-intensive Australian university comprised of a mix of large faculties, composed from loosely cognate disciplinary fields (e.g. engineering encompassing computing, civil engineering, chemical engineering), and cross-faculty interdisciplinary research institutes.

Purposeful sampling, common in phenomenographic research (Bowden and Green 2005), was employed. We reviewed course handbooks and identified interdisciplinary courses. The criteria were as follows:

- (1) The course was described using terms 'multidisciplinary', 'interdisciplinary' or other synonyms, and
- (2) The course had a project component, with teams composed of students from than one disciplinary field.

A pool of 80 undergraduate courses was identified from across the breadth of the university's structures and disciplinary fields. Employing a maximum variation strategy, we then purposefully selected specific courses from this pool and contacted course convenors aiming to identify people who had leadership roles and made substantial intellectual contributions to the conceptualisation, creation, design or redesign, or enactment of these interdisciplinary courses (we call them 'course leaders'). We contacted course convenors gradually until we recruited enough participants with the desired characteristics. A total of 59 potential participants were contacted, 36 responded, 23 of them met all sampling criteria and agreed to participate.

After conducting 23 interviews it was observed that no new understandings were forthcoming. As the sample was diverse, it was decided that sufficient data had been gathered. This sample size was within the suggested range of 20–30 participants to enable sufficient variation, while avoiding an unmanageable amount of data to analyse (Bowden and Green 2005).

The final sample included 12 women and 11 men, with academic experience from 2 to 30 years (Table 1). Twelve participants held lecturer-level positions (lecturer or senior lecturer), and 11 participants held professorial-level positions (associate or full professor). The sample was distributed among participants affiliated with different disciplinary areas, including Sciences (4), Business and Law (4), Engineering and Design (4), Arts, Humanities and Social Sciences (5), and Medicine and

Table 1. Profiles of study participants.

Participant ID	Academic level	Years in academia	Disciplinary area	Years leading interdisciplinary courses
1	Professor	16+	Arts, Humanities and Social Sciences	3
2	Lecturer	6–10	Sciences	2
3	Lecturer	0–5	Business and Law	2
4	Lecturer	11–15	Medicine and Health	4
5	Lecturer	0–5	Engineering and Design	2
6	Lecturer	6–10	Business and Law	3
7	Lecturer	6–10	Engineering and Design	2
8	Professor	11–15	Sciences	2
9	Professor	11–15	Engineering and Design	6
10	Professor	11–15	Medicine and Health	3
11	Lecturer	11–15	Business and Law	3
12	Professor	16+	Arts, Humanities and Social Sciences	4
13	Professor	16+	Medicine and Health	5
14	Lecturer	11–15	Medicine and Health	3
15	Professor	11–15	Engineering and Design	5
16	Lecturer	6–10	Arts, Humanities and Social Sciences	1
17	Lecturer	16+	Arts, Humanities and Social Sciences	4
18	Professor	16+	Medicine and Health	5
19	Lecturer	0–5	Business and Law	2
20	Lecturer	16+	Sciences	4
21	Professor	16+	Sciences	4
22	Professor	16+	Arts, Humanities and Social Sciences	7
23	Professor	16+	Medicine and Health	7

Participants' anonymity has been protected by removing identifying information and tagging quotations from their interviews with a participant identification number (e.g. P4).

Health (6). All courses that participants focussed upon were open to undergraduate students, and six were also open to postgraduate students.

Data collection and analysis

Semi-structured phenomenographic interviews (Åkerlind 2018) using videoconferencing were conducted. Both audio and video data were recorded and additional information about courses and participants' profiles was collected from the university's website in accordance with the University of Sydney's human research ethics committee's approved ethics protocol (approval #2020/668).

The participants were asked a range of questions about interdisciplinary teaching and learning, including: 'What does interdisciplinarity mean to you?'. This was followed by a range of probing questions, including, 'How do you understand it?' and 'What is the purpose of interdisciplinarity?'.

Analysis aimed to characterise the variation in how the phenomenon appeared to participants (Marton 1986). It started during the interviewing process and was guided by Åkerlind's (2012) iterative process which involves sorting data and comparing them with and against other similar quotes, with consideration of how they relate to the categories of description being constructed. To enhance trustworthiness (Åkerlind 2005), the analysis was performed by two members of the research team: the first two authors.

The analysis involved initial work by the first author: (1) transcription of recordings; (2) identification of data relevant to answering the research question from the entire corpus; (3) initial coding of transcripts by semantic meaning into preliminary 45 codes (4–12 supporting quotes each); and (4) grouping of the preliminary codes by semantic similarity into four initial categories;

and (5) construction of tables with quotes exemplifying key meanings in each code and category. The rest of the work was done by the two authors together: (6) comparing and contrasting initial codes and categories using shared tables and refinement into 3 categories; (7) review of the categories against the entire corpus of data to ensure no relevant data was missing and the included quotes were correctly interpreted; (8) identification of dimensions of variation to make differences between the categories more explicit and minor refinements of the categories; and (9) final review of the resulting categories and dimensions, and the quotes that support them to create a coherent and justifiable outcome space.

Results

Three ways of understanding interdisciplinarity

The outcome space included three categories of description and three dimensions of variation (Table 2). Course leaders expressed how they understand interdisciplinarity in relation to (A) definitions, (B) knowledge spaces, and (C) knowledge work. Three dimensions of variation, which existed across the three categories, represented how participants (1) conceive of interdisciplinarity, (2) use language to express their understanding of interdisciplinarity, and (3) formed their understanding of interdisciplinarity. No participant expressed an understanding solely in relation to definitions, and all participants expressed their understanding in 2–3 different ways, suggesting that their understanding of interdisciplinarity was grounded in multiple encounters with the phenomenon, ranging from definitions to sense-making to authentic disciplinary and interdisciplinary work experiences.

The categories of description and dimension of variation are presented below with supporting quotes to illustrate them. Participants’ anonymity has been protected by removing identifying information and by tagging quotations from their interviews with a participant identification number in brackets (e.g. P4). Italics are used for emphasis of important aspects of statements, and ellipsis were used to denote that irrelevant text was omitted from participants’ statements.

Category A: interdisciplinarity is understood in relation to definitions

In Category A, participants expressed their understanding of interdisciplinarity in relation to institutional definitions, or those found in interdisciplinary literature. Although participants emphasised definitions to convey meaning, they exhibited limited confidence in definitions of interdisciplinarity to effectively convey their understandings.

First, some participants emphasised the lack of agreement and clarity around definitions, illustrated in these examples:

Table 2. Outcome space: course leaders’ understandings of interdisciplinarity and variations between them.

Categories /Dimensions of variation			
	Category A	Category B	Category C
	In relation to definitions	In relation to knowledge spaces	In relation to knowledge work
	Understandings interdisciplinarity draw on the assumption that a correct understanding and/or definition exists, but is unclear	Interdisciplinarity is understood in relation to spatial terms and the interactions that happen between disciplines, boundaries, diverse knowledges, or systems	Interdisciplinarity is understood in relation to knowledge work
1. Conception	A correct meaning exists	Multiple meanings are possible and acceptable	Meanings are situated in activity
2. Language	Focus on comprehension	Focus on sense-making using spatial words	Focus on authentic meaning-making and acceptance of uncertainty
3. Formation	Knowledge sharing	Knowledge consolidation	Knowledge construction

I know there's a big debate. You know, I've heard people feel very strongly about specific meanings. (P12)

it's hard to know and to define (P1)

Even though some course leaders had substantial interdisciplinary experience, some of them struggled to articulate their understanding and tried to do this by referring to how interdisciplinarity is commonly understood:

Interdisciplinarity as I understand it, I think that a lot of people would argue ... you have different, different perspectives or different disciplinary perspectives coming together to try and answer questions that may not either be asked or solved with a single disciplinary perspective. So, in that respect I would say, well yes actually, maybe that is interdisciplinary, and I am interdisciplinary (but) then at the same time ... *I'm sorry, you're asking me questions that I haven't reflected on. So, I'm struggling with it.* (P23)

Others referred to a definition used within the institution. For example:

Well, I can define it as *not* combining two science programs, which is how it's often interpreted at the university. (P4)

However, this institutionally provided definition was perceived to be problematic by some other participants:

I remember (leadership) kept saying it's not physics and maths, right? So, physics and maths actually have a unit together. *So, I think everyone's thrown that out the window* (P20)

Other participants emphasised the difficulty and usefulness in differentiating and articulating the meaning of different related terms to convey a meaning of interdisciplinarity:

I once read an article which went through the definitions for multidisciplinary, interdisciplinary, transdisciplinary, all that stuff. *I don't remember any of it. I kind of bundled them all together.* (P5)

In this category, participants expressed the conception that a correct or 'pure' normative understanding of interdisciplinarity exists. This is evidenced in the following statements:

We use the term interdisciplinary, and I think I probably wasn't really across all of that theory, and I'm probably still not (P20)

I'm not sure that [program name] is the best interdisciplinarity – in its *pure form* (P11)

The language participants used in this category focused on declarative knowledge and its comprehension. Nouns included 'definitions' (P5), 'terms' (P20), 'theory' (P20) and 'specific meanings' (P12). Verb use related to expressing comprehension, such as to 'know what it means' (P11, P19), to 'know and define' (P1), to 'have an idea' (P7), and to 'have an understanding' (P11), and to 'remember' (P5).

Participants learned and formed their understanding of interdisciplinarity through reading interdisciplinary literature. This sometimes was aided by discussions and peer support:

There were people that sort of suddenly came out of the woodwork around the campus ... who wanted to talk, and that was of enormous value, and directed me to some interdisciplinary literature (P20)

To summarise, in Category A participants attempted to describe interdisciplinarity in relation to definitions, both encountered in the literature and locally used. However, despite the focus on definitions, the central emphasis in this category was one of critique, noting a general lack of confidence in both the usefulness and the comprehensibility of definitions to articulate an understanding of interdisciplinarity.

Category B: interdisciplinarity is understood in relation to knowledge spaces

In Category B, participants described interdisciplinarity in relation to knowledge spaces where disciplines or other forms of expertise met and interacted in different ways. Understandings were also described as sense-making of the interactions between different knowledges.

The use of spatial terms was evident in this category. Some participants focussed solely on how disciplines interacted with each other:

Interdisciplinarity means *moving between* disciplines, *working between* disciplines, *bringing* different disciplines together to achieve something that cannot be achieved through application of one specialization by itself. (P9)

Some participants focused on boundaries when describing interactions spatially:

You need to be able to prove that you're working, or define what interdisciplinarity might be, in terms of boundaries. And *if you're not working outside the boundaries, then you're not doing* [it] (P18)

Similarly, some other participants described interdisciplinarity as interaction between disciplines even if they problematised the use of term 'disciplines', noting that they are not static:

I think, in a very basic nutshell, bringing two disciplines to do something is interdisciplinary. However, the traditional definition of a discipline has evolved itself, that's what makes this a bit harder to tease out exactly ... that's not clear. (P8)

Some participants in this category went beyond classical disciplines and described interdisciplinarity in relation to complex systems, or as a separate meta-area or meta-disciplinary field:

Well, *it's all about understanding a complex system*. I mean, is that a skill? It's a new level of understanding. It's a new way of framing ... *It's a conception of the world* (P13)

Another participant extended a systems view of interdisciplinarity, arguing that interdisciplinarity did not inherently need to be grounded or built upon the construct of disciplines:

The term I like currently in my team is anti-disciplinary. This idea, the metaphor that, in the map of human knowledge all the disciplines are dots on a page. Well, they're interested in the white on the paper, not the dots. And that's what they call anti-disciplinary. I am interested in that too ... How do you live in your dot, live in your depth and specialism, but how do you work, create, and produce in the white space? (P14)

Nevertheless, in this category, interdisciplinarity was always conceived as a space where different knowledges come together. However, participants did not express that there was any single 'right' way of understanding interdisciplinarity. Participants accepted and supported people's diverse ways of sense-making. This is evidenced in the following example:

I'm finding that *interdisciplinarity means so many different things to different people*. And *it's such an open space*. It's quite *interesting to see how people bring their way of thinking and working to an understanding of what this massive, unbound spaces actually is* (P15)

The language participants used was diverse in relation to the subjects of interactions, including disciplines, boundaries, expertise, and systems. Participants' verb use was prepositional – signifying position, direction, and interaction between subjects. These included: '*bringing together*' different disciplines (P9) as well as people from different disciplines (P11, P17), '*combining disciplines*' (P3), '*fitting together*' disciplinary theories (P16), '*integrating*' theories (P16), perspectives (P20), backgrounds (P11), and knowledge and methods (P19), as well as '*fusing different disciplines together*' (P11) and '*melding*' ideas, knowledge, skills, behaviours, and attitudes (P10).

Learning and the formation of a personal understanding of what interdisciplinarity means in this category emphasised intellectual sense-making efforts. This focussed on mentor-supported learning and involved dialogue, tools, resources, and guidance which provided different ways of framing interdisciplinarity in the ongoing construction of meaning. For example:

We caught up more or less for coffee and a chat ... [academic mentor] shared some templates from her work, and pointed me to relevant resources ... I came at it from complexity and systems theory, which is one big part, but there are many others. She pointed me to soft systems methodology and the systems of systems. So, I still had to learn a lot myself ... it's a learning journey (P6)

Overall, participants in this category expressed an understanding of interdisciplinarity using spatial descriptions (e.g. moving between, spaces, boundaries, dots). Their understanding of disciplines was

often the starting point for articulating the meaning of interdisciplinarity. Simultaneously, they challenged the view that interdisciplinarity can be neatly described as interaction between disciplines. Unlike Category A in which participants referred to the external definitions, in Category B, participants drew more prominently on their reasoning and reflections to construct understandings.

Category C: interdisciplinarity is understood in relation to knowledge work

In Category C, participants expressed an understanding of interdisciplinarity by focussing on problem-centered work, knowledge creation practices, and ways of working with uncertainty. Rather than describing what interdisciplinarity was, or how disciplines interact, participants described interdisciplinarity in relation to how knowledge work was accomplished:

Ultimately, interdisciplinarity is something *you do* (P23)

Some participants described interdisciplinarity as problem-centered work:

It means that we should be attacking problems without regard to disciplinary boundaries or straight-jackets. (P22)

It's about the diversity of knowledge that, put into a coherent theme, how they come together to solve problems. *This can go the other way around as well. You have a problem that needs diversity of knowledge to find a solution.* (P2)

Some participants focussed on the creative component of interdisciplinary work rather than on solving problems, describing it as working with uncertainty and creating new epistemic practices and methods. Despite complexity and uncertainty, their answers featured epistemic confidence and awareness:

For me *it's absolutely normal to not know what you're making.* And to set out together with deep expertise, and to be absolutely confident that you're going to get it. And that's it. That's what I expect when I'm working with people in an interdisciplinary way (P14)

For example, one participant described interdisciplinarity as being 'in everything that *I do*' and noted:

Sometimes we come up with a really hard problem, *we don't have the statistical techniques that are available for us to answer this.* So, we've got to come up with new stuff. *So, we come up with new theory and methods* (P21)

Participants conceptualised an understanding of interdisciplinarity as varied and situated in the context of the work being done and emerging. This is evidenced in the following comments:

You're basically bolting together a factory, and you bring everybody together to make one product, once and then you disassemble the factory, and everybody goes home. And ... what you're making has never been made before, so it has to be entirely original. (P14)

The language used to describe interdisciplinarity signified aims, strategy, and creativity and described non-routine, creative knowledge practices constructed to support knowledge co-creation and reduction of uncertainty. Phrases included to 'create something new' (P11), to 'create new knowledge' (P11), to 'come up with new ways of doing, and new ways of looking' (P11), to 'come up with new theories and methods' (P21), and to 'reduce uncertainty' (P21).

Learning and formation of personal understanding of what interdisciplinarity is, was described as stemming from, and happening in, hands-on interdisciplinary knowledge co-creation activity. This included course leaders' creation of an interdisciplinary course. For example:

In order for us [course leaders] to design the [student] interdisciplinary project, it effectively made us do an interdisciplinary study ... In fact, we ran it as if we were part of a unit, in which the outcome was to actually create a unit ...

We had cultural competency between all of us coming from different backgrounds, we did collective decision making, and we actually achieved all the graduate qualities that were intended for graduates, but as academics (P8)

Central to this category is participants' descriptions of interdisciplinarity as non-routine, collaborative, creative, and adaptive knowledge work. An understanding of interdisciplinarity is situated in the knowledge work being done.

Relationships between the categories

The differences between the three categories of description as well as the relationships between them were most visible when looked via three dimensions of variation.

In Dimension 1, participants’ conceptions of interdisciplinarity advanced from the idea that there was likely a correct way of understanding interdisciplinarity, to the idea that multiple acceptable understandings could exist, to the idea that understanding is situated in interdisciplinary activity and is context-dependant and variable. In Dimension 2, the language participants used to convey their understanding shifted from a focus on comprehension of interdisciplinarity, to sense-making using prepositional verbs to signify position, direction and interaction between disciplines, boundaries, expertise, or systems within a broader knowledge space, then to authentic meaning-making focusing on creative ways of working and addressing uncertainty. In Dimension 3, revealing how participants formed an understanding of interdisciplinary, the focus shifted from sharing knowledge and resources, to gradually expanding one’s horizon and consolidating understanding by reflecting on the intersections of different knowledge spaces, to participating in authentic interdisciplinary knowledge work in teams.

Together these dimensions provide insights into the structural relationships between the three ways of understanding interdisciplinarity. Progressing across the categories of description, participants express increasingly authentic meaning-making, epistemic awareness, and confidence in their understandings. In Category A, participants’ statements reflected a rationalist epistemological position conveying that a correct meaning of interdisciplinarity existed and it could be acquired from external sources. In Category B, participants’ statements reflected a constructivist epistemological position, emphasising that no fixed understanding of interdisciplinarity existed and understanding could be constructed through an individual’s sense-making. Multiple and changing understandings were perceived as both possible and acceptable. In Category C, participants expressed a pragmatist epistemological position, emphasising the applied nature of interdisciplinary practices, focussing on concrete aims. Understandings were tied to situated contexts, and at times collectively constructed or negotiated (Table 3).

Furthermore, all course leaders expressed understandings which traversed the three categories and dimensions of variation in different ways. For instance, P20 made multiple statements relating to definitions of interdisciplinarity in category A to describe an understanding, but also used language in relation to the integration of perspectives from different disciplines in category B. P15 similarly critiqued normative understandings from category A as ‘a philosophical discussion’ to preface a description of interdisciplinarity as a ‘massive unbound space’ where people ‘bring different ways of thinking and working’ belonging to category B. Other course leaders similarly pre-faced the understandings they expressed in relation to common definitions by recognising existing debates (P12) and arguing against understandings provided by the institution (P4). Additionally, five of the participants expressed understandings belonging to all three categories. For example, P11 described interdisciplinarity as having a ‘pure form’, as ‘fusing different disciplines together’, as well as ‘coming up with new ways of doing and new ways of looking’ to ‘create new knowledge’. These examples show the variety in how meaning is constructed by course leaders. Some course leaders expressed meaning drawing on two or more different categories, while others critiqued normative understandings in category A to articulate understandings in relation to categories B and C.

Table 3. Referential and structural components of course leaders’ understandings of interdisciplinarity.

Referential component Focus on the ‘what’ of understandings	Structural components focus on the ‘how’ of understandings
Understood in relation to definitions	Rationalist epistemological position
Understood in relation to knowledge spaces	Constructivist epistemological position
Understood in relation to knowledge work	Pragmatist epistemological position

Discussion

Our findings provide three main contributions to the study of interdisciplinary teaching and learning.

First, participants' understandings of interdisciplinarity reflected definitions and stances on interdisciplinarity discussed in the literature but did not adopt any single definition outright. Instead, participants drew on definitions, extended them, or expressed constructed understandings by challenging them. Course leaders' views reflected but did not fully adopt understandings such as the integration of disciplines and various typologies (Klein 1990; 2017), social and spatial metaphors (Downey et al. 2019), sense-making (Nikitina 2005), anti-disciplinarity (Pickering 2013), creative epistemic practices (Knorr-Cetina 1999) and systems (Ison 2017). Participants also described interdisciplinarity in diverse and, at times, conflated ways (Graff 2016) and challenged assumptions about disciplines as fixed and well-formed (Brew 2008; Lindvig and Ulriksen 2019; Pinch 1990). While course leaders' understandings of what interdisciplinarity means had connections to normative definitions and theoretical views, they simultaneously diverged significantly from them.

Second, our findings show that most course leaders expressed multiple or entangled ways of understanding interdisciplinarity. The majority of course leaders' constructed understandings that reflected, but were not limited to definitions in category A. All course leaders expressed understandings belonging to categories B and, or C. Vienni Baptista et al. (2020) have described this as having multiple, heterogeneous, and plural understandings. Our findings support but extend this description. Our findings show a distinct emphasis placed on course leaders' construction of their own understandings of interdisciplinarity rather than accepting or holding multiple commonly accepted understandings of interdisciplinarity. DeZure (2017) argues that understandings of interdisciplinarity evolve and are ongoingly constructed through ongoing investigation of the field. Our findings show that understandings of interdisciplinarity are also constructed *within individuals* through sensemaking and in interdisciplinary work. More apparent than accepting or holding multiple or plural normative understandings of interdisciplinarity, course leaders construct diverse understandings in relation to normative understandings.

Third, understandings in each of the three categories reflected distinct epistemological positions advancing from rationalist to constructivist, to pragmatist positions. Advancing from category A to C, course leaders' views become increasingly more problem-centered and focussed on understandings of what interdisciplinarity is when people *do* interdisciplinarity. Advancing across the three categories, they also reflected increased participants' grounding of their responses in personal experiences, epistemic confidence in dealing with uncertainty and epistemic awareness of how interdisciplinary work is done. Many of our participants were researchers and curriculum innovators, and their expressed understandings of interdisciplinarity were reflected through their experiences gained doing complex creative knowledge work, often drawing heavily upon their understandings of interdisciplinarity from research, and at times, design experiences. However, our findings also show that experience alone is not enough to articulate an understanding of interdisciplinarity. Despite having significant experience, participants who had not previously engaged in reflective practices about interdisciplinarity struggled to articulate their understandings.

Conclusions

Our study sheds light on how interdisciplinarity is understood by those who lead interdisciplinary courses. The phenomenographic approach enabled us to map the outcome space and systematically investigate the variance and relationships between different understandings. These findings significantly extend prior studies that pointed out the multiplicity of ways in which interdisciplinarity is understood but did not investigate the relationships between varied understandings of interdisciplinarity.

Our findings demonstrated that while familiarity with interdisciplinary literature and institutionally-accepted definitions can be foundational for developing an understanding of interdisciplinarity,

a sole focus on how interdisciplinarity is defined could limit a broader and deeper understanding of interdisciplinarity. Such deeper understanding draws on personal sense-making of how disciplinary and other kinds of knowledge are created, and authentic engagement in interdisciplinary knowledge work.

The findings also show that course leaders describing their understanding of interdisciplinarity adopted different epistemological stances and shifted between them. The rationalist position and normative understandings of interdisciplinarity were never the only way course leaders framed their understanding of interdisciplinarity. This is an important distinction to make as non-normative explanations of interdisciplinarity are often described in the literature as confusions or misunderstandings. Our results suggest that it could be more productive to acknowledge different possible ways of framing, explaining, and understanding interdisciplinarity to help practitioners see differences and connections between them. The constructed outcome space can be used as a starting point to elicit and discuss diverse ways of understanding interdisciplinarity and to support the development of epistemic awareness about what practitioners mean when they say 'interdisciplinarity'. Alternatively, the development of mutually acknowledged understandings could be particularly important in the context of interdisciplinary education as what is meant by interdisciplinarity also connects to how it is learnt.

We acknowledge that further research is required to investigate the relationship between beliefs and actual practice, noting that research on understandings risks telling 'half the story' (Kane, Sanderetto, and Heath 2002) and would benefit from further research on practices. Our findings provide a starting point for such research. Additionally, we acknowledge that awareness alone is insufficient to improve teaching; a sustained, systematic approach that involves critical reflection on both practices and outcomes is required as well (Trigwell and Prosser 1996). Further support and guidance, as well as time and opportunities are essential to enacting theory-informed change in practices (Hughes et al. 2023).

Our aim was to study the variance in ways course leaders from across the breadth of a university's disciplines and faculties understand interdisciplinarity. Acknowledging that understandings of interdisciplinarity are situated, our study does not claim generalizability to other contexts. Future studies could investigate how institutionally-accepted understandings influence understandings of interdisciplinarity in practice. We have investigated course leaders' understandings, but a similar phenomenographic approach could be used to study students' understanding of interdisciplinarity and the relationships between students' understandings and course leaders' understandings. This could help inform the development of mutual or mutually acknowledged understandings of interdisciplinarity across a university and support more systematic approaches to advancing interdisciplinary education.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by Australian Research Council [grant number DP200100376].

Statements and declarations

This research was partly funded by the Australian Research Council through Discovery Project grant DP200100376 (Developing interdisciplinary expertise in universities). The authors report there are no other competing interests to declare.

ORCID

Dwayne Ripley  <http://orcid.org/0000-0002-7812-0614>
 Lina Markauskaite  <http://orcid.org/0000-0002-3470-890X>
 Peter Goodyear  <http://orcid.org/0000-0001-9903-737X>

References

- Åkerlind, Gerlese S. 2005. "Academic Growth and Development – How Do University Academics Experience It?" *Higher Education* 50 (1): 1–32. <https://doi.org/10.1007/s10734-004-6345-1>.
- Åkerlind, Gerlese S. 2012. "Variation and Commonality in Phenomenographic Research Methods." *Higher Education Research & Development* 31: 115–27. <https://doi.org/10.1080/07294360.2011.642845>.
- Åkerlind, Gerlese S. 2018. "What Future for Phenomenographic Research? On Continuity and Development in the Phenomenography and Variation Theory Research Tradition." *Scandinavian Journal of Educational Research* 62 (6): 949–58. <https://doi.org/10.1080/00313831.2017.1324899>.
- Albert, Mathieu, Pia Vuolanto, and Suzanne Laberge. 2023. "Re-Appraising Disciplines: A Commentary." *Studies in Higher Education* 48 (3): 413–23. <https://doi.org/10.1080/03075079.2022.2140334>.
- Barry, Andrew, Georgina Born, and Gisa Weszkalnys. 2008. "Logics of Interdisciplinarity." *Economy and Society* 37 (1): 20–49. <https://doi.org/10.1080/03085140701760841>.
- Boix Mansilla, Veronica, William C. Miller, and Howard Gartner. 2000. "On Disciplinary Lenses and Interdisciplinary Work." In *Interdisciplinary Curriculum: Challenges of Implementation*, edited by Sam Wineburg, and Pamela Grossman, 53–67. New York: Teachers College Press.
- Boon, Mieke, Sophie van Baalen, and Marleen Groenier. 2019. "Interdisciplinary Expertise in Medical Practice: Challenges of Using and Producing Knowledge in Complex Problem-Solving." *Medical Teacher* 41 (6): 668–77. <https://doi.org/10.1080/0142159X.2018.1544417>.
- Bowden, John A., and Pam Green. 2005. *Doing Developmental Phenomenography*. Melbourne: RMIT University Press.
- Brew, Angela. 2008. "Disciplinary and Interdisciplinary Affiliations of Experienced Researchers." *Higher Education* 56 (4): 423–38. <https://doi.org/10.1007/s10734-007-9102-4>.
- Cooke, Steven J., Vivian M. Nguyen, Dimitry Anastakis, Shannon D. Scott, Merritt R. Turetsky, Alidad Amirfazli, Alison Hearn, et al. 2020. "'Diverse Perspectives on Interdisciplinarity from Members of the College of the Royal Society of Canada.'" Edited by Jules M. Blais." *Facets* (1): 138–65. <https://doi.org/10.1139/facets-2019-0044>.
- DeZure, Debora. 2017. "Interdisciplinary Pedagogies in Higher Education." In *The Oxford Handbook of Interdisciplinarity*, edited by Robert Frodeman, Julie Thompson Klein, and Roberto Carlos Dos Santos Pacheco, 558–72. Oxford: Oxford University Press. <https://doi.org/10.1093/oxfordhb/9780198733522.013.45>.
- Downey, Gregory J., Noah Weeth Feinstein, Daniel Lee Kleinman, Sigrid Peterson, and Chisato Fukuda. 2019. "The Frictions of Interdisciplinarity: The Case of the Wisconsin Institutes for Discovery." In *Investigating Interdisciplinary Collaboration: Theory and Practice Across Disciplines*, edited by Scott Frickel, Mathieu Albert, and Barbara Prainsack, 47–64. New Brunswick, NJ: Rutgers University Press. <https://doi.org/10.36019/9780813585918-005>.
- Franks, Daniel, Patricia Dale, Richard Hindmarsh, Christine Fellows, Margaret Buckridge, and Patti Cybinski. 2007. "Interdisciplinary Foundations: Reflecting on Interdisciplinarity and Three Decades of Teaching and Research at Griffith University, Australia." *Studies in Higher Education* 32 (2): 167–85. <https://doi.org/10.1080/03075070701267228>.
- Goodyear, Peter. 2018. "Design Research." *Health Education in Practice: Journal of Research for Professional Learning* 1 (1): 7–17.
- Graff, Harvey J. 2016. "The "Problem" of Interdisciplinarity in Theory, Practice, and History." *Social Science History* 40 (4): 775–803. <https://doi.org/10.1017/ssh.2016.31>.
- Graff, Harvey J. 2021. "Interdisciplinarity Is Not About the Humanities Aping the Sciences." Times Higher Education (Blog). September 6, 2021. <https://www.timeshighereducation.com/blog/interdisciplinarity-not-about-humanities-aping-sciences>.
- Hughes, Gwyneth, David Baume, Ayona Silva-Fletcher, and Linda Amrane-Cooper. 2023. "Developing as a Teacher: Changing Conceptions of Teaching and the Challenges of Applying Theory to Practice." *Teaching in Higher Education*, 1–16. <https://doi.org/10.1080/13562517.2023.2212589>.
- Ison, Ray. 2017. *Systems Practice: How to Act: In Situations of Uncertainty and Complexity in a Climate-Change World*. 2nd ed. London: Springer London. <https://doi.org/10.1007/978-1-4471-7351-9>.
- Kane, Ruth, Susan Sandretto, and Chris Heath. 2002. "Telling Half the Story: A Critical Review of Research on the Teaching Beliefs and Practices of University Academics." *Review of Educational Research* 72 (2): 177–228. <https://doi.org/10.3102/00346543072002177>.
- Kidron, Adi, and Yael Kali. 2015. "Boundary Breaking for Interdisciplinary Learning." *Research in Learning Technology* 23 (1): 26496. <https://doi.org/10.3402/rlt.v23.26496>.
- Klein, Julie T. 1990. Interdisciplinarity: History, Theory, and Practice. <https://doi.org/10.1604/9780814320877>

- Klein, Julie Thompson. 2017. "Typologies of Interdisciplinarity." In *The Oxford Handbook of Interdisciplinarity*, edited by Robert Frodeman, Julie Thompson Klein, and Roberto Carlos Dos Santos Pacheco, 21–34. Oxford: Oxford University Press. <https://doi.org/10.1093/oxfordhb/9780198733522.013.3>.
- Knorr-Cetina, Karin. 1999. *Epistemic Cultures: How the Sciences Make Knowledge*. Cambridge, Mass: Harvard University Press. <https://doi.org/10.1604/9780674258945>
- Lattuca, Lisa. 2003. "Creating Interdisciplinarity: Grounded Definitions from College and University Faculty." *History of Intellectual Culture* 3 (1): 1–20.
- Lindvig, Katrine, and Line Hillersdal. 2019. "Strategically Unclear? Organising Interdisciplinarity in an Excellence Programme of Interdisciplinary Research in Denmark." *Minerva* 57 (1): 23–46. <https://doi.org/10.1007/s11024-018-9361-5>.
- Lindvig, Katrine, Catherine Lyall, and Laura R. Meagher. 2019. "Creating Interdisciplinary Education Within Monodisciplinary Structures: The Art of Managing Interstitiality." *Studies in Higher Education* 44 (2): 347–60. <https://doi.org/10.1080/03075079.2017.1365358>.
- Lindvig, Katrine, and Lars Ulriksen. 2019. "Different, Difficult, and Local: A Review of Interdisciplinary Teaching Activities." *The Review of Higher Education* 43 (2): 697–725. <https://doi.org/10.1353/rhe.2019.0115>.
- Lyall, Catherine, Laura Meagher, Justyna Bandola, and Ann Kettle. 2015. "Interdisciplinary Provision in Higher Education – Current and Future Challenges." Higher Education Academy. <https://www.advance-he.ac.uk/knowledge-hub/interdisciplinary-provision-higher-education-current-and-future-challenges>.
- Markauskaite, Lina. 2020. "Commentary: Learning for Knowledge Work Practices in the Wild." *Research Papers in Education* 35 (1): 105–15. <https://doi.org/10.1080/02671522.2019.1677762>.
- Marton, Ference. 1986. "Phenomenography – A Research Approach to Investigating Different Understandings of Reality." *Journal of Thought* 21 (3): 28–49.
- Nersessian, Nancy J. 2019. "Interdisciplinarity in Action: Cognitive Ethnography of Bioengineering Sciences Research Laboratories." *Perspectives on Science* 27 (4): 553–81. https://doi.org/10.1162/posc_a_00316.
- Nikitina, Svetlana. 2005. "Pathways of Interdisciplinary Cognition." *Cognition and Instruction* 23 (3): 389–425. https://doi.org/10.1207/s1532690xci2303_3.
- Nowotny, Helga. 2019. "Prologue: The Messiness of Real-World Solutions." In *Investigating Interdisciplinary Collaboration: Theory and Practice Across Disciplines*, edited by Scott Frickel, Mathieu Albert, and Barbara Prainsack, 1–4. New Brunswick, NJ: Rutgers University Press. <https://doi.org/10.36019/9780813585918-002>
- Pickering, Andrew. 2013. "Ontology and Antidisciplinarity." In *Interdisciplinarity: Reconfigurations of the Social and Natural Sciences*, edited by Andrew Barry, and Georgina Born, 247–72. Abingdon: Routledge.
- Pinch, Trevor. 1990. "The Culture of Scientists and Disciplinary Rhetoric." *European Journal of Education* 25 (3): 295. <https://doi.org/10.2307/1503319>.
- Repko, Allen F., Rick Szostak, and Michelle Phillips Buchberger. 2017. *Introduction to Interdisciplinary Studies*. 2nd ed. Los Angeles: Sage.
- Sills, David L. 1986/2016. "A Note on the Origin of 'Interdisciplinary.'" Items, May 3, 2016. <https://items.ssrc.org/from-our-archives/a-note-on-the-origin-of-interdisciplinary/>.
- Trigwell, Keith, and Michael Prosser. 1996. "Congruence Between Intention and Strategy in University Science Teacher's Approaches to Teaching." *Higher Education* 32 (1): 77–87. <https://doi.org/10.1007/BF00139219>.
- Vienni Baptista, Bianca, Isabel Fletcher, Maciej Maryl, Piotr Wciślik, Anna Buchner, Catherine Lyall, Jack Spaapen, and Christian Pohl. 2020. "Final Report on Understandings of Interdisciplinary and Transdisciplinary Research and Factors of Success and Failure". <https://doi.org/10.5281/zenodo.3824839>

Chapter 5: Course Leaders' Conceptions of the Purpose of Interdisciplinary Education

This chapter is an article first published online by Springer in the Journal *Higher Education* on 28 Nov 2024.

Ripley, D., Markauskaite, L. (2024). Course leaders' conceptions of the purpose of interdisciplinary education. *Higher Education*. <https://doi.org/10.1007/s10734-024-01360-5>

Note: this article contains an erratum in Data availability statement. The correct Data availability statement is "The participants of this study did not give written consent for their data to be shared." The request to publish this erratum was submitted to the publishers on 29 Nov 2024.

Conceptions of the purpose of interdisciplinary education may vary. Brew et al. (2022) argue that universities have room to improve on how their strategic ambitions are communicated, understood, and enacted at all levels. This article in this chapter investigates how course leaders conceive of the purpose of interdisciplinary education and is interrelated with how course leaders understand interdisciplinarity (Chapter 4). Together they lay the foundation for investigating course leaders' experiences of designing for interdisciplinary teaching and learning (Chapters 6–8). See Figure 2.1 to view how the chapters are interrelated.

This article is in its submitted form and does not reflect the peer-reviewed suggestions provided by the publisher. This will need to be addressed following the submission of this thesis (due to time constraints).

For this article, I conducted data collection, data analysis, and the original draft preparation and revisions based on feedback from both supervisors and from two anonymous peer reviewers. Lina Markauskaite was responsible for reviewing and editing multiple drafts of the paper and conducting data analysis. My contribution to the paper is estimated at 75% and my supervisors at 25%.



Course leaders' conceptions of the purpose of interdisciplinary education

Dwayne Ripley¹ · Lina Markauskaite¹

Accepted: 7 November 2024
© The Author(s) 2024

Abstract

Universities are expanding the number of interdisciplinary courses they offer. These courses are often developed at the fringes of universities and academic departments by course leaders who often have significant design and teaching autonomy. Course leaders' conceptions of the purpose of interdisciplinary education shape their decisions about course outcomes, content, and educational approaches, yet little is known about the rationales underlying their choices. This study uses phenomenographic interviews to address the question: How do interdisciplinary course leaders conceive of the purpose of interdisciplinary education? Outcomes from interviews with 23 leaders at an Australian university show five conceptions of purpose that are: (A) enrichment-oriented, (B) employability-oriented, (C) integration-oriented, (D) epistemically-oriented, and (E) society-oriented. Some of these course leaders' conceptions reflect common instrumental purposes of interdisciplinary education that focus on preparing students to work in interdisciplinary teams and workplaces. However, some conceptions extend beyond instrumental purposes to include the development of students' epistemic and relational capabilities aiming to prepare them to engage with novel, open-ended forms of knowledge work. The created outcome space offers a reflective tool that course leaders and other stakeholders can use to support their discussions about the purposes of interdisciplinary education. It also could serve as a starting point for curriculum planning and design.

Keywords Interdisciplinary Education · Course Leaders · Conceptions of Purpose · Higher Education · Phenomenography

✉ Dwayne Ripley
dwayne.ripley@sydney.edu.au

Lina Markauskaite
lina.markauskaite@sydney.edu.au

¹ Sydney School of Education and Social Work, The University of Sydney, Camperdown, NSW 2006, Australia

Introduction

Interdisciplinary curricula are becoming more mainstream in higher education (DeZure, 2017). Purposes for this expansion cited in the literature are diverse, including preparing students for employment in the knowledge economy (Moore & Morton, 2017), solving society's complex problems and grand challenges (Ashby & Exter, 2019), and living full, informed lives within dynamic knowledge societies (Mansilla, 2017). However, perceptions of what drives interdisciplinary education can vary, and there can be mismatches between the rationales for interdisciplinary education and the institutional structures and practices in place to support the implementation of the rationales (Lyall et al., 2015). In a study of interdisciplinarity in Denmark, Lindvig (2022) describes this as a discord between the *loud voices* that represent how interdisciplinary education is promoted and the *soft voices* that represent interdisciplinary education in practice.

Variation in purpose is not uncommon. Universities do not function as linear organisations and mismatches between rationales and practices often exist (Brew et al., 2022). In Australia, instrumental purposes are commonly emphasised in interdisciplinary curricula (Millar, 2016), prioritising direct, practical benefits for students, such as employability and the development of sets of skills from established knowledge domains (Gombrich & Hogan, 2017). However, Australian university teachers, similarly as interdisciplinary teachers in other countries, such as Denmark, commonly have significant autonomy in making decision what to teach and how to teach (Lindvig & Ulriksen, 2019). In the UK, teachers responsible for enacting interdisciplinary education often have limited detailed institutional guidance on what students are expected to learn and how (Lyall et al., 2015). Although instrumental conceptions of interdisciplinary education are common in interdisciplinary education (Klein, 2017), they are insufficient to describe the variance in nuanced and contextualised arrangements of interdisciplinary education in practice (Øland et al., 2022). For example, in the US, there can be significant variance between comprehensive universities and liberal arts colleges (Klein, 1990).

In this paper, we present a phenomenographic study that investigates how academics who lead or contribute substantially to conceptualising, designing, or enacting interdisciplinary courses (we call them '*course leaders*') conceive of the purpose of interdisciplinary education. We identify different conceptions of purpose and map out the relationships between them by exploring key dimensions that underpin them. Our research question is,

How do interdisciplinary course leaders conceive of the purpose of interdisciplinary education?

Our outcomes show that course leaders conceive of the purposes of interdisciplinary education in diverse ways, ranging from instrumentally-oriented conceptions, which value practical outcomes, to epistemically and socially-oriented conceptions, which emphasise students' agency and the transformative role of interdisciplinary knowledge work in society. These different purposes are associated with different capabilities, different framings of who learns and in what contexts, different motives, and different approaches to learning activities.

These outcomes provide important insights into what course leaders think and aim to achieve when designing and teaching interdisciplinary courses. They can be used as a starting point in joint reflections and discussions about the purposes of interdisciplinary

education and, in turn, facilitate a better understanding of how to support or change interdisciplinary educational practices. As Biesta (2016) explains, efforts to improve education effectiveness begin with consideration of educational purposes, and our study's outcomes directly contribute to advancing the understanding of the purposes that underpin current interdisciplinary teaching and learning practices.

In this paper, we use the term 'interdisciplinary education' as a broad umbrella term that includes developing students' capabilities to work with people from different disciplinary, professional, or other (e.g., industry, community) backgrounds to co-construct knowledge for different purposes. It is inclusive of the terms multidisciplinary, interdisciplinary, and transdisciplinary—terms that are often used interchangeably in educational literature (Fam et al., 2018). Our broad, encompassing definition does not assume that this term is uniformly defined, understood, and used by different people. Instead, it enables us to be open to different interpretations and terminological variations that are often observed in interdisciplinary literature and practitioners' discourses (Barry & Born, 2013; Ripley et al., 2024).

To situate our study, we first review dominant perspectives on the purpose of interdisciplinary education in universities and literature on academics' perceived purposes of interdisciplinary education.

Purposes of interdisciplinary education in universities

Much of the literature on the purposes of interdisciplinary education draws on reviews of higher education policies, trends, and other public discourses. While this literature is vast, four interrelated, and partially overlapping perspectives are prominent.

First, since the 1990s, there has been a pervasive focus on student employability and job readiness in tertiary education in Australia (Moore & Morton, 2017). This perspective is representative of the push for Australian universities to become more interdisciplinary in instrumental, job-focused ways (Maassen et al., 2018). A second overlapping perspective emphasises the development of students' 21st-century skills needed in the workplace and beyond, including teamwork, critical thinking, and communication (Millar, 2016). This perspective focuses on developing students' agile, transferrable skills that extend beyond specialised disciplinary or professional knowledge (Lyll et al., 2015). The emphasis on preparing students with 21st-century skills can be found in both industry reports on the future of work (OECD, 2023) and in Australian academic reports on industry placements (Brewer et al., 2022). A third perspective from an American study emphasises developing students' complex problem-solving capabilities to prepare them to respond to global challenges (Ashby & Exter, 2019), such as climate change, chronic diseases, food security, and the unintended negative impact of technological advances. This perspective focuses on equipping students with the skills and knowledge necessary to solve complex problems, particularly in scientific and professional environments (Millar, 2016; Spelt et al., 2009). The fourth perspective focuses on developing students' capacities to synthesise and integrate disciplinary knowledge, methods, and tools to work with knowledge in ways that are beyond what is possible by any single discipline (DeZure, 2017).

These four perspectives largely view interdisciplinarity in instrumental terms and frame interdisciplinary education as a means to develop students' personal capabilities to achieve concrete, practical outcomes, such as gaining employment or succeeding in diverse academic and professional contexts. Each of these four perspectives has attracted significant critique in the academic literature. First, Hart (2019) criticises the job readiness literature

for lacking objective measurement of skills for employability, instead relying on teachers' and students' perceptions of employability skills development. Second, Millar (2016) argues that the link between interdisciplinary curricula and the development of twenty-first century skills is an assumed link. Third, Boon et al. (2019) critique integrative learning for oversimplifying complex problem-solving. Other authors also argue that complex systemic problems require more than learning instrumental skills in advance; they require sensitivity to contextual details, 'moral know-how,' empathy, and other qualities needed for social learning, developed through multiple interactions with different stakeholders (Goodyear & Markauskaite, 2019; Ison et al., 2021). Fourth, Mansilla (2017) brings attention to the lack of transparency and detail in how integration is accomplished, characterising it as "the philosopher's stone of interdisciplinary efforts, capable of turning diffuse disciplinary insights into valuable understandings" (p. 263). Boon et al. (2019) support this characterisation, identifying that little is known about how to design for synthesis and integration in higher education. Overall, central to these critiques of all four perspectives is that they either oversimplify the complexity of interdisciplinary knowledge work or are too vague about the nature of the capabilities required or how to develop them.

Whereas the literature on the general purposes of interdisciplinary education is substantial, research on how practitioners understand the purposes of interdisciplinary education is limited. Lindvig and Ulriksen's (2019) review of empirical studies on interdisciplinary teaching identifies two main focuses of purpose. One focus is on the capabilities that students are expected to develop, including competences for collaboration, disciplinary awareness, creativity, and innovation. The second purpose focusses on the motivational potential of interdisciplinary learning by making some topics more relevant to students. These integrated outcomes provide important insights into how academics perceive the purposes of interdisciplinary education. However, further detail is needed.

It is important to recognise that the purposes of interdisciplinary education do not exist in isolation but are situated alongside other purposes within universities. Brew et al. (2022) touch upon this multiplicity of purposes, noting that "teaching decisions lie at the confluence of individual and collective aims, aspirations, and desires and at intersections between different values" (p. 946). Literature on the future of universities also acknowledges multiple purposes, including preparing students for personal success in an increasingly complex world and preparing students to contribute to the advancement of society (Connell, 2019; Kemmis, 2023; Markauskaite & Goodyear, 2017). This body of literature places a significant focus on the role of knowledge and students' awareness of how knowledge is created. This perspective is common in the literature on learning in diverse interdisciplinary work settings, including interdisciplinary research laboratories (Nersessian, 2022), change-oriented development projects (Ison et al., 2021), and other cross-disciplinary practices (Hubbs et al., 2021), but largely absent from the four purposes of interdisciplinary education reviewed.

Methodology

In this study, we used a phenomenographic approach, originally developed by Marton (1981), to investigate how interdisciplinary course leaders conceive of the purpose of interdisciplinary education. Phenomenography is used to map out the qualitatively different ways a phenomenon is understood, perceived, and experienced (Marton, 1986). It is a methodology that continues to evolve with researchers interpreting, understanding, using

it in different ways and debating its application and terms (Åkerlind, 2005, 2022, 2023; Tight, 2016). Phenomenography espouses a non-dualist ontology that does not separate objective and subjective experiences. Rather than investigating an objective phenomenon ‘out there’ in the world or subjective experiences of a phenomenon, phenomenography investigates the relationship between a phenomenon and how the phenomenon is experienced. It accomplishes this by investigating ways of experiencing something as the unit of study (Marton & Booth, 1997). The role of phenomenographic research is not simply to present a set of distinctly different conceptions but to provide a logical structure between them.

Phenomenography has been used to study diverse phenomena in education, such as how experienced researchers conceptualise their disciplinary and interdisciplinary affiliations (Brew, 2008), and how academics conceive of teaching and learning (González, 2011). Phenomenography has a strong empirical focus (Bowden & Green, 2005), which makes it a well-suited approach to explore variations in conceptions of the purpose of interdisciplinary education. Additionally, it is an established methodology for investigating different conceptions of a phenomenon across the breadth of a university’s faculties and disciplinary structures (Barrie, 2012), which helps generate practical, actionable knowledge useful for institutional decision-making (Ellis & Goodyear, 2019).

Context and sampling

The study was conducted at a large, Australian public research university comprised of numerous faculties and schools. The study’s protocol was approved by the University of Sydney’s human research ethics committee (Approval #2020/668).

Purposeful sampling, common in phenomenographic studies (Bowden & Green, 2005), was used to select course leaders.

Initially, a pool of 80 interdisciplinary courses offered at the university was identified by reviewing course handbooks. Two criteria were used: (1) a course description had to contain the word ‘interdisciplinary’ or similar terms, including ‘multidisciplinary’ and ‘transdisciplinary’; and (2) a course had to include an interdisciplinary project work component. These courses included capstone projects, courses focused on innovation, and other courses available to students from multiple disciplinary backgrounds.

Next, using maximum variation sampling (Bowden & Green, 2005), a sample of potential interdisciplinary courses representing the full range of the university’s organizational structures and disciplinary areas was selected. Course convenors of the selected courses were gradually contacted. In total, 59 possible participants were approached, of which 36 responded. The recruitment stopped after completing 23 interviews, as no significantly new responses were emerging in the last interviews, and the sample size was within the recommended range of 20–30 participants, a size large enough to enable sufficient variation while avoiding an overwhelming amount of data to analyse (Bowden & Green, 2005).

Course leaders’ backgrounds are summarised in Table 1. The final sample included 12 women and 11 men. Twelve participants had lecturer-level positions (Lecturer or Senior Lecturer), and eleven participants had professorial-level positions (Associate Professor or Professor). Participants came from a variety of fields, including the sciences (4), business and law (4), engineering and design (4), the arts, humanities, and social sciences (5), and medicine and health (6). All courses that participants described were available to undergraduate students, but six courses were also available to graduate students.

Table 1 Participant profiles

Participant ID	Academic level	Years in academia	Disciplinary area	Years leading interdisciplinary courses
1	Professor	16+	Arts, Humanities and Social Sciences	3
2	Lecturer	6–10	Sciences	2
3	Lecturer	0–5	Business and Law	2
4	Lecturer	11–15	Medicine and Health	4
5	Lecturer	0–5	Engineering and Design	2
6	Lecturer	6–10	Business and Law	3
7	Lecturer	6–10	Engineering and Design	2
8	Professor	11–15	Sciences	2
9	Professor	11–15	Engineering and Design	6
10	Professor	11–15	Medicine and Health	3
11	Lecturer	11–15	Business and Law	3
12	Professor	16+	Arts, Humanities and Social Sciences	4
13	Professor	16+	Medicine and Health	5
14	Lecturer	11–15	Medicine and Health	3
15	Professor	11–15	Engineering and Design	5
16	Lecturer	6–10	Arts, Humanities and Social Sciences	1
17	Lecturer	16+	Arts, Humanities and Social Sciences	4
18	Professor	16+	Medicine and Health	5
19	Lecturer	0–5	Business and Law	2
20	Lecturer	16+	Sciences	4
21	Professor	16+	Sciences	4
22	Professor	16+	Arts, Humanities and Social Sciences	7
23	Professor	16+	Medicine and Health	7

Data generation

Semi-structured interviews were carried out using videoconferencing and were audio/video recorded. Additional background information was collected from the public university's website. Each interview lasted 50–90 min, in which course leaders were asked a range of questions related to their experiences creating and leading interdisciplinary courses. One of the key questions was, 'What do you consider the goal of interdisciplinary education to be?'. This was followed by probing questions (Bowden & Green, 2005) aimed at eliciting more information or clarifying answers. These follow-up questions were chosen from a list of potential supplementary questions to probe participants' responses further.

Analysis

Data analysis drew on phenomenographic techniques (Åkerlind, 2012; Marton, 1986). Phenomenographic research generates categories of description which relate to ways of experiencing, as well as an outcome space which is constructed of categories of description that shows different aspects of the phenomenon and the relationships between them (Marton & Booth, 1997). Whereas the categories are organised hierarchically in relation to participants' increasing awareness of the phenomenon, the dimensions provide a means to explore and map out the relationships between categories. Together, they form a *space* of outcomes that maps out variation and enables exploration of the relationships between different conceptions of purpose through their component dimensions.

Åkerlind's (2012) iterative method of comparing and sorting the semantic meaning of statements against those of other similar statements was used as a starting point for analysis. This method helped create the categories of description and dimensions of variation. To increase trustworthiness, both authors conducted analysis collaboratively and reviewed the outcome space several times after receiving external feedback until a coherent and defensible outcome space was developed.

Below are the categories and dimensions of variation, with quotes to support them. The anonymity of participants is protected through the removal of identifying information and by tagging quotations from all interviews with a participant identification number (e.g., P3). Ellipsis are used to identify when less relevant text is removed from quotes, and italics are used to emphasise important aspects of statements.

Outcomes

Purposes of interdisciplinary education

The analysis resulted in five categories of description and four dimensions of variation. The purpose of interdisciplinary education was conceived as: (A) enrichment-oriented, (B) employability-oriented, (C) integration-oriented, (D) epistemically-oriented, and (E) society-oriented. These five categories formed a spectrum of increasingly elaborate conceptions of purpose, advancing from Category A to Category E, with each increasingly elaborate conception being inclusive of less elaborate purposes in the spectrum. Additionally, four dimensions of variation existed across the categories, representing: 1) the *capabilities* that students are expected to develop (i.e., what is learned), 2) learning *activities* (i.e., the how of learning), (3) the *framing*, which reflects how students are positioned in relation to collective learning in which context (i.e., who learns and in what context), and 4) the *motive* or object for interdisciplinary education (i.e., the why of learning). Table 2 shows structural links between the categories of description and the dimensions of variation.

Category A: Enrichment-oriented

In Category A, interdisciplinary education was described in terms of the enrichment of students' disciplinary awareness and capabilities to work with others to contribute to interdisciplinary teamwork:

Table 2 Conceptions of the purpose of interdisciplinary education

Category	Category A Enrichment-Oriented	Category B Employability-Oriented	Category C Integration-Oriented	Category D Epistemically-Oriented	Category E Society-Oriented
Dimension					
Capabilities (What)	Disciplinary awareness and interpersonal skills	Workplace readiness and performance of workplace practices	Capabilities to synthesise and integrate perspectives	Epistemological awareness of different disciplinary ways of working with knowledge	Social and affective capabilities and agency to work with different knowledge cultures in society
Activities (How)	Direct teaching and learning and self-reflection	Participation in simulated workplace practices	Participation in simulated problem solving	Dialogue and reflection on diverse knowledge practices	Agentic, value-led, and creative engagement in interdisciplinary work
Framing (Who in relation to what context)	Students as individuals learning to work in interdisciplinary teams	Students as individuals learning to work in interdisciplinary workplaces	Students as members of collectives in relation to a problem	Students as individuals in relation to diverse disciplinary knowledge cultures within an academic team context	Students as individuals in relation to diverse knowledge cultures in non-academic, non-routine collaborative configurations
Motives (Why)	To know what and how to contribute to interdisciplinary teamwork	To be prepared for an interdisciplinary workplace and to gain a competitive advantage when seeking employment	To produce solutions to complex problems	To have deep epistemological understanding enabling engagement in diverse kinds of interdisciplinary knowledge work	To lead positive change in unstructured, real world interdisciplinary environments

It's maybe something around... *personal development*. (P15)

Activities to support students' personal development included critical self-reflection and direct instruction. For example:

It's about having some *very specific exercises* that you do with students that help them to identify what their discipline is, what the strengths of that discipline is, and then *some reflections* on where the limitations might be. (P12)

We *needed to create some workshops...* to give students opportunities to learn these skills... one was collective decision making, how do groups work... and one on cultural competency and interpersonal skills. (P8)

Students were framed as working in teams but were positioned as individuals, developing skills to work in an interdisciplinary team to enhance their understandings of their own disciplines in relation to members from other disciplines:

By putting them into different teams... to work with people of other disciplines, to start to see the limitations of, and boundaries of their own disciplinary thinking. (P15)

Having to *work with people from different disciplinary backgrounds* is now just an everyday routine... so, equipping our students with such necessary skills and understandings should be a part of the higher education experience. (P17)

The motive for broadening students' disciplinary understanding was to enable them to use their disciplinary knowledge in practical situations. For example:

They have a lot of knowledge that is given to them from their own discipline... "*How is what I know useful in making something work?*" (P19)

Overall, in this category, course leaders conceived of the purpose of interdisciplinary education as enriching individual students' disciplinary awareness and interpersonal capabilities. This prepared students to understand what disciplinary knowledge they could contribute to interdisciplinary teamwork, and how to contribute it effectively in interdisciplinary teams.

Category B: Employability-oriented

In Category B, the purpose of interdisciplinary education was described as preparing students for future employment. Course leaders emphasised developing students' capabilities for workplace tasks, such as working with realistic data or writing industry-oriented reports:

We gave them... real world scenarios they can go and solve and with the lab, we gave them some experiments to do... *real world working with data*. So, if they go to work in industry, they can use that. (P7)

What I want from my students is for them to, at the end of the semester, *produce a team group report, that is of the character of what a consulting firm or NGO or think tank might produce*. And of course, a consulting firm, NGO or think tank doesn't have separate disciplines. (P22)

To achieve this purpose, course leaders aimed to engage students in immersive, experiential learning activities that involved doing relevant workplace tasks:

...thinking about the design was more about the practicalities and – “what was the sequence of events that’s real? So, thinking about how does this journey of a prescription happen? When do the different professions intervene? How do they communicate together?” So, *we tried to keep it as authentic and real as possible.* (P10)
 A good result for me is students coming out and being able to operate in these environments more effectively... and *although we’re not spending a great deal of time explicitly teaching how to work in an interdisciplinary environment, they are working in an interdisciplinary environment in the classroom.* (P9)

Similar to Category A, students were positioned as individual learners, but this time in relation to interdisciplinary workplace practices. Emphasis was again placed on students’ individual contributions to interdisciplinary teamwork. For example:

The ways in which we contribute meaningfully are through interdisciplinary work. (P23)

As soon as you’ve finished learning in a classroom, everything you do requires interdisciplinary work... *it all comes down to how we apply our knowledge*, and the authentic application of our knowledge is through interdisciplinary work. (P23)

The motive was to develop students’ employability by giving them experiences with interdisciplinary workplace environments. Additionally, there was a pronounced perception that interdisciplinary learning could help students gain a competitive advantage when seeking employment:

Just having training in [single discipline] is not something that is going to get you a job in most cases. (P4)

I think it gives graduates an advantage in the market - it’s like having a second way of thinking essentially. (P15)

Overall, in this category, the purpose of interdisciplinary education was oriented towards both students’ employability and their workplace-readiness. Central to this was presenting students with possibilities to have workplace experiences, but did not describe how students should work together in interdisciplinary teams.

Category C: Integration-oriented

In Category C, the purpose of interdisciplinary education was emphasised as preparing students to bring together different perspectives in service of solving complex problems. Course leaders emphasised the development of students’ capabilities for synthesis and integration of various perspectives:

We were encouraging this kind of integration through... not just reporting on separate perspectives but *bringing it together in... a product.* (P20)

To integrate... to come out with something that explains the issue or addresses the research questions *in light of our combined insights.* (P1)

Learning activities were mainly oriented towards experiential learning, but without significant guidance or scaffolding:

It’s more of setting it up so that they are just doing that [integrating perspectives], rather than actually asking them to [integrate]. (P20)

Students were no longer positioned as individual learners, but instead as team members who could collectively learn and bring together varied disciplinary perspectives:

They need to put themselves in a larger group than their own discipline in order to have a *real impact*. (P13)

...they have to show how they have tackled the research question, and how they *come up with a kind of integrated outcome* that takes into account the different disciplines represented in the group. (P1)

The motive for interdisciplinary education was the assumption that the integration of disciplinary and other perspectives is necessary for effective solutions to complex problems:

Most of the problems... are not business as usual problems. They are now so complex that we *need a range of different perspectives to come to useful effective solutions*. (P6)

It's really important... *to achieve that goal of synthesis, to achieve that goal of getting those multiple perspectives*. (P20)

Overall, in this category, course leaders conceived of the purpose of interdisciplinary learning as developing students' capabilities to synthesise and integrate different *perspectives* for solving complex problems.

Category D: Epistemically-oriented

In Category D, students' epistemic awareness about different ways of working with knowledge, including how different academic disciplines create and validate knowledge was described. The purpose of interdisciplinary education was to develop students' foundational epistemological understanding necessary to work across disciplines:

There are *philosophies around epistemology and ontology*... but the students are at a point where they haven't practiced research, they haven't developed the idea of applying methodologies and where they've come from... *it has to be embedded somewhere*. (P20)

I start with a *little bit of philosophy of science*... there are different worlds here intellectually. (P3)

Various dialogic and reflective activities that expose students to disciplinary differences and prompt them to think deeply about epistemic aspects of interdisciplinary knowledge work were seen as critical for achieving this purpose.

We were doing this [interdisciplinary course activity] ... and the [different disciplinary] *academics spent half the time arguing*, saying, 'that's not right. That's not the way we think'. For the students to experience *that was really valuable*. (P18)

Look into that aspect of, how do you design, collaborate, co-create in these groups?... You've got all those dynamics at play [during interdisciplinary groupwork] and *if you're not explicit about them and get people to reflect on them, they don't really learn how to do it themselves*. (P14)

Students were positioned as part of diverse interdisciplinary collectives, and the emphasis was on each student's personal epistemological awareness about various ways of knowing and disciplinary differences usually encountered in academic contexts:

If it's to be interdisciplinary, it does need a bit more thought given *to how you make different disciplines work together...* to reflect on different methods and different research approaches. (P11)

The motive was to prepare students to collaborate with people who do not share their epistemological perspective:

That's the reality of the world, the problems that we are facing as humanity. They require interdisciplinary collaboration... to have that kind of *engagement with people from different paradigms... or epistemological beliefs*. (P16)

It's bringing people together from different disciplines, different ways of thinking, and different cultures... *Students bring together different ways of doing things, whether it's research or knowledge, and there a connecting point to something different happening, something new* (P11)

Overall, in this category, interdisciplinary education was primarily oriented towards building students' epistemic awareness about disciplinary differences necessary for interdisciplinary teamwork in diverse academic contexts. In contrast with Category A where the main focus was on students' own discipline and the immediate task at hand, in Category D, the main focus was on building a much broader epistemological foundation necessary to understand and work with different academic disciplinary knowledges and knowledge practices.

Category E: Society-oriented

In Category E, the purpose of interdisciplinary education was expressed as preparing students to lead knowledge creation in service of society and engage with varied partners and stakeholders from both within and beyond the academic settings.

The development of students' social and affective capabilities to work with diverse stakeholders was emphasised. This included not only the capabilities to collaborate effectively with them, but also to learn from them, be inclusive, empathetic, and proactively receptive to different kinds of knowledge and ways of knowing that exist outside academic settings. An important part of this purpose was to develop students' flexibility, values, and agentic capabilities:

If we actually were able *to work with others more effectively*, you've got the potential of dealing with social issues much better. (P11)

We want to create [courses] that promote leaders that create results and *actually change things...* for the better. (P3)

Learning activities focussed on the development of student agency to frame problems and imagine futures in relation to students' own interests, dispositions, and motivations:

...having that voice to bring their passion and their interests and their concerns into their education. (P16)

Imagine that you had all the data in the world, *what question would you be asking?* (P21)

Students were once again positioned individually as a part of collectives, but the focus expanded from established academic collaborations to working collectively with partners and stakeholders from various knowledge cultures in wider society:

To adapt, be flexible, learn to hear other people, and learn to listen... that's really vital to what they're going to end up doing in the real world. (P11)

The motive for interdisciplinary education in this category also expanded from developing students' instrumental capabilities to working more effectively in interdisciplinary teams in unscripted and emergent ways to make positive changes in society.

If you can engage in the blank page. If you can listen carefully, you can be respectful if you can, and if you can offer suggestions in a non-judgmental way. If you can do these whole lot of things, and there's a high degree of trust... something original can arise – something new, something unexpected. I think in educational terms, that's a very high-level act. And that's the level we have to be working at to solve the future. (P14)

Overall, in this category, the purpose of interdisciplinary education was to prepare students to instigate and lead knowledge co-creation to make positive change in society. This involved working with knowledge and ways of knowing not only within, but also beyond the university.

Together, these five categories composed a spectrum of different ways that the purpose of interdisciplinary education was conceived of by course leaders.

Relationships between the categories

The differences and relationships between course leaders' conceptions of purpose were most visible when explored through the four identified dimensions of variation.

In Dimension 1, the *capabilities* course leaders intended students to develop expanded from largely instrumental interdisciplinary capabilities to students' values and identities. Category A aligned with developing students' disciplinary awareness, skills, and what and how they can contribute to interdisciplinary teamwork. Category B aligned with developing students' employability via developing capabilities related to performing workplace practices. Category C aligned with fostering students' capabilities for synthesising and integrating perspectives in service of producing solutions to problems. Category D aligned with developing students' capabilities including epistemic awareness about different ways of creating and working with knowledge and associated challenges in interdisciplinary knowledge work. Lastly, Category E aligned with developing social and affective capabilities, and agency to work with different people, and knowledge beyond the boundaries of the university.

In Dimension 2, learning activities for achieving the intended purposes of interdisciplinary education included a significant hands-on component that was complemented by other activities. These activities expanded from an emphasis on direct learning and self-reflection in Category A to an emphasis on simulated, experiential learning activities in Categories B and C, then an emphasis on dialogue and reflection on diverse knowledge practices in Category D, and lastly an emphasis on imaginative, creative activities focussed on students' values and agency in Category E.

In Dimension 3, learning was *framed* in different ways, expanding from individual students positioned in relation to other members within a team to students positioned as working with a diversity of potential stakeholders. In Category A, students were positioned as individuals learning to work in interdisciplinary student teams. In Category B, they were positioned as individuals developing their employability through participation in interdisciplinary workplace practices. In Category C, the focus expanded to students

being positioned as members of collectives learning together to produce joint solutions to complex problems through mastering knowledge synthesis and integration. In Category D, students were positioned in relation to collectives of people from different disciplines in an academic context, and in Category E, in relation to people outside of the university from different knowledge cultures in wider society. In these last two categories, the framing expanded to include students being positioned in relation to collectives with epistemically more diverse enquiry practices across varying interdisciplinary contexts.

In Dimension 4, *motives* for interdisciplinary education expanded from the focus on individual needs and personal benefits for students to the needs and benefits for society. Category A aligned with broadening students' understanding of what and how they can contribute to interdisciplinary work. Category B aligned with preparing students for interdisciplinary workplaces and gaining a competitive advantage over others when seeking employment. Both of these motives were oriented towards the benefits to individual students. Category C aligned with producing effective collective solutions to complex problems. Category D aligned with developing students' deep epistemological understanding, enabling them to engage in diverse kinds of interdisciplinary knowledge work. Lastly, Category E aligned with preparing students to lead and make positive change in society. The motives in the final three categories extended beyond students' personal benefits to include direct and indirect benefits to society.

Table 2 sets out the outcome space as a whole, including how the five different categories of description are situated within it. The dimensions of variation provide the structural aspects of participants' accounts. The highlighted sections show the progression in what is foregrounded (shaded and in bold font) and backgrounded (no shading or bold font) moving from Category A to E. For example, the acquisition of capabilities is foregrounded in Category A. Then activities are foregrounded in Categories B and C, including participating in workplace practices and participating in simulated problem solving, respectively. Then, framing is foregrounded in Category D, focusing on the relationship between individuals and diverse disciplinary knowledge cultures within academic team contexts. Lastly, motives are foregrounded in Category E, focussed on students leading positive change in unstructured environments.

It is important to note that the categories of description advance hierarchically from Category A to E, with each category being inclusive of prior categories, and additional dimension of variation foregrounded in each category. In this outcome space, inclusivity advances along both the vertical and horizontal axes. This shows the interrelation between the relational and structural aspects of the outcome space. Moving from Category A to E, and from the capability dimension to the motive dimension. Advancing from the top left to the bottom right of the outcome space, more dimensions of variation are foregrounded, representative of the increased complexity in how the purpose of interdisciplinary education is conceived of, being more inclusive of the interdependency of the aspects of what, how, who, and why of interdisciplinary education.

Discussion and conclusions

This study investigated the variance in how interdisciplinary course leaders conceptualise the purpose of interdisciplinary education. While these purposes have been discussed widely in various reports and reviews (Lindvig & Ulriksen, 2019; Millar, 2016; Moore & Morton, 2017), to our knowledge, this is the first empirical study that addresses this

question. It advances the current understanding of interdisciplinary education by systematically mapping out an outcome space that presents a logical structure between the different conceptions of the purpose of interdisciplinary education.

The outcomes align with five distinct conceptions of the purpose of interdisciplinary education: (A) enrichment-oriented, (B) employability-oriented, (C) integration-oriented, (D) epistemically-oriented, and (E) society-oriented. Investigation of these conceptions in relation to four dimensions of variation—(1) intended capabilities (*what* is taught), (2) framing of learning (*who* learns and *in what* context), (3) motivations for interdisciplinary teaching (*why* it is beneficial), and (4) learning activities (*how* students learn)—contribute further important insights into what course leaders think and aim to achieve when designing and teaching interdisciplinary courses. These outcomes provide insight into how course leaders' conceptions of purpose view instrumental perspectives on the purpose of interdisciplinary education, as well as purposes that extend beyond these dominant perspectives.

The first three categories mirror the instrumental purposes of interdisciplinary education commonly reported in the literature (Maassen et al., 2018; Millar, 2016; Moore & Morton, 2017), but show course leaders' distinct interpretations. In the enrichment-oriented category, course leaders focus on extending students' disciplinary learning and developing their capabilities that are broadly consistent with twenty-first century skills (OECD, 2023), shown in the quotes, to 'see the limitations of, and boundaries of their own disciplinary thinking' (P15) and to 'work with people from different disciplinary backgrounds' (P17). This view of purpose firmly builds on students' disciplinary learning and sees interdisciplinary education as an enhancement to it. While interdisciplinary literature often emphasises the foundational role of disciplines in interdisciplinary practices (Mansilla, 2017; Millar, 2016), in contrast, in this category, course leaders also emphasise the critical role of interdisciplinary learning in enriching students' disciplinary understanding and practices. This mutually constitutive relationship between disciplinary and interdisciplinary learning has been largely overlooked in the interdisciplinary education literature.

The emphasis on students' capabilities to 'get a job' (P4) and to 'operate more effectively' (P20) in workplaces align with the employability-oriented category, which are broadly consistent with the employability agenda (Moore & Morton, 2017). The main focus of interdisciplinary education is to develop students' abilities to apply disciplinary knowledge to workplace-related practices, and in doing so, to help students gain employment. This conception also builds on students' disciplinary learning. However, in this category, the application of disciplinary knowledge is not just an incremental step, as it is in the enrichment-oriented category, but a learning experience that leads to qualitatively different learning outcomes—'a second way of thinking' (P15). However, this second way of thinking is framed as more cumulative than integrative.

The focus on students' capabilities to 'get multiple perspectives' (P20) and bring them 'together in... a product' (P20) align with the integration-oriented category and are consistent with integrative learning (Mansilla, 2017) and complex problem-solving perspectives (Ashby & Exter, 2019). In this category, similar to observations in the literature on integrative perspectives (Boon et al., 2019; Mansilla, 2017), the purpose of interdisciplinary education was the least articulated. Even further, while the literature often describes synthesis and integration as encompassing disciplinary *knowledge, methods, and tools* (DeZure, 2017), in contrast, course leaders in our study described synthesis and integration using a much broader term, '*perspectives*'. Course leaders emphasised integrated outcomes and framed learning as a collective, experiential endeavour, which made details related to what individual students do and what they learn less central to the purpose of interdisciplinary education and, therefore, obscure and ill-defined. This lack of articulation and detail

renders the mechanics of integrative interdisciplinary learning vague and, therefore, difficult to effectively design for and to measure.

The last two categories focus on developing students' epistemic and relational capabilities. The overarching rationale that guides these purposes is practical—to prepare students for the complexity and challenges of engaging with different knowledge and ways of knowing in emergent contexts. However, in these categories, course leaders expand their focus from developing students' instrumental capabilities to accomplish specific interdisciplinary tasks and achieve tangible, immediate outcomes to include the development of broader capabilities that underpin students' flexibility and agency to work with and create knowledge in a variety of interdisciplinary contexts.

The focus on developing students' epistemological awareness by introducing students to 'the philosophy of science' (P3) and giving them an opportunity to think about 'how you make different disciplines work together' (P11) align with the epistemically-oriented category. The development of students' epistemological awareness has rarely been found as a key purpose in empirical studies of interdisciplinary education (Lindvig & Ulriksen, 2019; Lyall et al., 2015; Spelt et al., 2009). However, some literature on interdisciplinary research persuasively argues that team members' epistemological awareness is critical for successful interdisciplinary work (Hubbs et al., 2021; Nersessian, 2022). Course leaders similarly recognise the indirect but critical role of epistemological understanding in preparing students for future interdisciplinary teamwork.

The focus on the development of students' social and affective capabilities, such as the use of empathetic and inclusive approaches when working with people from different knowledge cultures includes an emphasis on students' instrumental needs and their 'passions and interests' and their 'concerns' (P16) and see them as a foundation for developing students' dispositions and agency to lead change in society which is aligned with the society-oriented category. This view of interdisciplinary education focuses on the dynamic, complex, uncertain, and flexible nature of complex interdisciplinary knowledge work, particularly when it extends to community and other non-academic settings. It is characterised by non-routine, ongoing individual and mutual learning in interdisciplinary work, not solely as individual learning in advance of interdisciplinary work. This perspective is common in transformation-oriented interdisciplinary projects (Ison et al., 2021), but rarely features in undergraduate education.

Overall, the last two categories represent the purposes that have been claimed to be 'neglected' (Boon & Van Baalen, 2019) or 'glossed over' (Millar, 2016) in interdisciplinary education. In contrast, our outcomes show that while they might be 'neglected' or 'glossed over' from a broader discourse, they are present in course leaders' conceptualisations. These purposes also echo current arguments about the changing nature of knowledge work and universities' critical mission to prepare graduates for engaged, skilful participation in knowledge work in diverse professional settings and society (Connell, 2019; Goodyear & Markauskaite, 2019; Markauskaite & Goodyear, 2017).

These outcomes, taken together, make three key contributions to the field of interdisciplinary education.

Firstly, the outcomes show that course leaders conceive of interdisciplinary education as contributing to different aspects of the university's mission, from preparing professionals with a deep understanding of their specialised domain capable of contributing to interdisciplinary teamwork to preparing future leaders capable of engaging with new open-ended forms of knowledge work.

Secondly, our outcomes show that commonly purported purposes for interdisciplinary education may not neatly map to course leaders' conceptions of purpose. While

these conceptions could be complementary, articulating these differences and relationships is important, as unacknowledged differences between the views of different stakeholders are a common source of tensions and inefficiencies in interdisciplinary teaching and learning (Lyll et al., 2015; Øland et al., 2022). Our created outcome space offers a reflective tool that course leaders, teachers, university leadership, external partners, and other stakeholders could use to support their discussions and align their views about the purpose of interdisciplinary education.

Thirdly, the created outcome space presents a logical structure that maps the relationships between different conceptions of purpose and gives insight into key aspects that underpin pedagogical decision-making, including what, who, why, and how students learn. Clearly articulated purposes support effective pedagogical choices (Biesta, 2016), and these outcomes could be a helpful starting point for reflection and discussion in interdisciplinary curriculum planning and design.

Nevertheless, it is important to acknowledge the limitations of this study and the areas that require further research.

First, interdisciplinary practices are situated and vary across countries, regions, universities, and specific settings (Nersessian, 2022; Øland et al., 2022). Additionally, there can be variance in the purposes and approaches to education in universities between those that are liberal arts, technology-centred, or comprehensive. Therefore, not all purposes of interdisciplinary education could be equally important in different contexts. As is common in phenomenographic research, our study identified and mapped out a spectrum of purposes at a single setting, an Australian comprehensive university. This study was predicated on the idea that conceptions of purpose are multiple and varied and identified and mapped out in detail the logical relationships between varied conceptions, but these findings are context specific and should not be universalised. Understanding contextual variations, particularly differences between the purposes of interdisciplinary education in comprehensive universities, liberal arts colleges, and other types of higher education that historically approached interdisciplinary education differently (Jung & Mok, 2023) is an important direction for future research.

Second, our study was based on a sample drawn from a single university. While the participants were sampled using a maximum variation strategy (Bowden & Green, 2005) and represented a spectrum of interdisciplinary courses and personal backgrounds, new conceptions could emerge if this sample is expanded to participants from other universities.

Third, our study investigated conceptions of the purpose of interdisciplinary education across course leaders only. Future studies could explore conceptions of the purpose of different stakeholders whose views and decisions shape interdisciplinary curricula, particularly university leadership and management. Additionally, course leaders in our study emphasised the importance of students' own purposes in their learning. Further studies could also investigate students' conceptions, which could help inform university policy and curriculum design.

Finally, it is important to recognise that academics' conceptions are just one contributing consideration and do not pre-determine their practices or students' outcomes (Kane et al., 2002; Kember, 1997). While making course leaders' conceptions explicit is important for understanding how interdisciplinary education is enacted and why, further research that investigates how course leaders enact these purposes is needed.

Acknowledgements This research was partly funded by the Australian Research Council through Discovery Project grant DP200100376 (Developing interdisciplinary expertise in universities).

Funding Open Access funding enabled and organized by CAUL and its Member Institutions. This work was partly funded by the Australian Research Council through Discovery Project grant DP200100376 (Developing interdisciplinary expertise in universities). All authors certify that they have no affiliations with or involvement in any organisation or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

Data availability Data de-identified by institution is available upon request from the first author.

Declarations

Competing interests The authors report there are no other competing interests to declare.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

References

- Åkerlind, G. S. (2005). Academic growth and development: How do university academics experience it? *Higher Education*, 50(1), 1–32. <https://doi.org/10.1007/s10734-004-6345-1>
- Åkerlind, G. S. (2012). Variation and commonality in phenomenographic research methods. *Higher Education Research and Development*, 31(1), 115–127. <https://doi.org/10.1080/07294360.2011.642845>
- Åkerlind, G. S. (2023). Common misunderstandings of phenomenographic research in higher education. *Higher Education Research and Development*, 43, 1–16. <https://doi.org/10.1080/07294360.2023.2218804>
- Ashby, I., & Exter, M. (2019). Designing for interdisciplinarity in higher education: Considerations for instructional designers. *TechTrends*, 63(2), 202–208. <https://doi.org/10.1007/s11528-018-0352-z>
- Barrie, S. C. (2012). A research-based approach to generic graduate attributes policy. *Higher Education Research and Development*, 31(1), 79–92. <https://doi.org/10.1080/07294360.2012.642842>
- Barry, A., & Born, G. (Eds.). (2013). *Interdisciplinarity: Reconfigurations of the social and natural sciences*. UK: Routledge. <https://doi.org/10.4324/9780203584279>
- Bennet, S., Agostinho, S., & Lockyer, L. (2017). The process of designing for learning; understanding university teachers' design work. *Educational Technology Research and Development*, 65(1), 125–145. <https://doi.org/10.1007/s11423-016-9469>
- Biesta, G. (2016). Improving education through research? From effectiveness, causality and technology to purpose, complexity and culture. *Policy Futures in Education*, 14(2), 194–210. <https://doi.org/10.1177/1478210315613900>
- Boon, M., & Van Baalen, S. (2019). Epistemology for interdisciplinary research – shifting philosophical paradigms of science. *European Journal for Philosophy of Science*, 9, 16. <https://doi.org/10.1007/s13194-018-0242-4>
- Boon, M., van Baalen, S., & Groenier, M. (2019). Interdisciplinary expertise in medical practice: Challenges of using and producing knowledge in complex problem-solving. *Medical Teacher*, 41(6), 668–677. <https://doi.org/10.1080/0142159X.2018.1544417>
- Bowden, J. A., & Green, P. (Eds.). (2005). *Doing developmental phenomenography*. RMIT University Press.
- Brew, A. (2008). Disciplinary and interdisciplinary affiliations of experienced researchers. *Higher Education*, 56(4), 423–438. <https://doi.org/10.1007/s10734-007-9102-4>
- Brew, A., Boud, D., Lucas, L., & Crawford, K. (2022). Hampering teaching excellence? Academics making decisions in the face of contradictions. *Studies in Higher Education*, 47(4), 941–952. <https://doi.org/10.1080/03075079.2020.1828327>

- Brewer, M., Lewis, S., & Ferns, S. (2022). Interdisciplinary work-integrated learning: Australian university project-based learning pilots and practices. *International Journal of Work-Integrated Learning*, 23(1), 17–30. <https://doi.org/10.12968/jpar.2019.11.8.348>
- Connell, R. (2019). The good university: What universities actually do and why it's time for radical change. *Zed Books*. <https://doi.org/10.1111/ajph.12605>
- DeZure, D. (2017). Interdisciplinary pedagogies in higher education. In R. Frodeman (Ed.), *The Oxford handbook of interdisciplinarity* (2nd ed., online edn, pp. 558–572). Oxford University Press. <https://doi.org/10.1093/oxfordhb/9780198733522.013.45>
- Ellis, R. A., & Goodyear, P. (2019). The education ecology of universities: Integrating learning, strategy and the academy. *Routledge*. <https://doi.org/10.4324/9781351135863>
- Fam, D., Leimbach, T., Kelly, S., Hitchens, L., & Callen, M. (2018). Meta-considerations for planning, introducing and standardising inter and transdisciplinary learning in higher degree institutions. In D. Fam, L. Neuhauser, & P. Gibbs (Eds.), *Transdisciplinary theory, practice and education* (pp. 85–102). Springer. https://doi.org/10.1007/978-3-319-93743-4_7
- Gombrich, C., & Hogan, M. (2017). Interdisciplinarity and the student voice. In R. Frodeman (Ed.), *The Oxford handbook of interdisciplinarity* (2nd ed., online edn, pp. 544–557). Oxford University Press. <https://doi.org/10.1093/oxfordhb/9780198733522.013.44>
- González, C. (2011). Extending research on 'conceptions of teaching': Commonalities and differences in recent investigations. *Teaching in Higher Education*, 16(1), 65–80. <https://doi.org/10.1080/13562517.2010.507302>
- Goodyear, P. & Markauskaite, L. (2019). The impact on practice of wicked problems and unpredictable futures. In J. Higgs, S. Cork, & D. Horsfall (Eds.), *Challenging future practice possibilities* (1 ed., pp. 41–52). Brill. https://doi.org/10.1163/9789004400795_004
- Hart, J. (2019). Interdisciplinary project-based learning as a means of developing employability skills in undergraduate science degree programs. *Journal of Teaching and Learning for Graduate Employability*, 10(2), 50–66. <https://doi.org/10.21153/jtlge2019vol10no2art827>
- Hubbs, G., O'Rourke, M., & Orzack, S. H. (Eds.). (2021). *The toolbox dialogue initiative: The power of cross-disciplinary practice*. CRC Press.
- Ison, R. L., Collins, K. B., & Iaquinto, B. L. (2021). Designing an inquiry-based learning system: Innovating in research praxis to transform science–policy–practice relations for sustainable development. *Systems Research and Behavioral Science*, 38(5), 610–624. <https://doi.org/10.1002/sres.2811>
- Jung, I., & Mok, K.-H. (2023). *The reinvention of liberal learning around the globe* (1st ed.). Springer.
- Kane, R., Sandretto, S., & Heath, C. (2002). Telling half the story: A critical review of research on the teaching beliefs and practices of university academics. *Review of Educational Research*, 72(2), 177–228. <https://doi.org/10.3102/00346543072002177>
- Kember, D. (1997). A reconceptualisation of the research into university academics' conceptions of teaching. *Learning and Instruction*, 7(3), 255–275. [https://doi.org/10.1016/S0959-4752\(96\)00028-X](https://doi.org/10.1016/S0959-4752(96)00028-X)
- Kemmis, S. (2023). Education for living well in a world worth living in. In K. E. Reimer, M. Kaukko, S. Windsor, K. Mahon, & S. Kemmis (Eds.), *Living well in a world worth living in for all* (pp. 13–25). Springer. https://doi.org/10.1007/978-981-19-7985-9_2
- Klein, J. T. (1990). *Interdisciplinarity: History, theory, and practice*. Wayne State University Press.
- Klein, J.T. (2017). Typologies of interdisciplinarity. In R. Frodeman (Ed.), *The Oxford handbook of interdisciplinarity* (2nd ed., online edn, pp. 21–34). Oxford University Press. <https://doi.org/10.1093/oxfordhb/9780198733522.013.3>
- Lindvig, K. (2022). Loud and soft voices of interdisciplinarity in higher education. In T. Øland, S. Sauzet, M. L. Ryberg, & K. Lindvig (Eds.), *Configurations of interdisciplinarity within education: Danish experiences in a global education space*. (1st ed., pp. 94–118). Routledge. <https://doi.org/10.4324/9781003083245-5>
- Lindvig, K., & Ulriksen, L. (2019). Different, difficult, and local: A review of interdisciplinary teaching activities. *Review of Higher Education*, 43(2), 697–725. <https://doi.org/10.1353/rhe.2019.0115>
- Lyall, C., Meagher, L., Bandola, J., & Kettle, A. (2015). *Interdisciplinary provision in higher education – current and future challenges*. University of Edinburgh. Retrieved June 20, 2023, from <https://www.advance-he.ac.uk/knowledge-hub/interdisciplinary-provision-higher-education-current-and-future-challenges>
- Maassen, P., Nerland, M., & Yates, L. (2018). Reconfiguring knowledge in higher education: Emerging themes and research avenues. In P. Maassen, M. Nerland, & L. Yates (Eds.), *Reconfiguring knowledge in higher education* (pp. 187–202). Springer. https://doi.org/10.1007/978-3-319-72832-2_11

- Mansilla, V. B. (2017). Interdisciplinary learning: A cognitive-epistemological foundation. In R. Froedman (Ed.), *The Oxford handbook of interdisciplinarity* (2nd ed., online edn, pp. 261–275). Oxford University Press. <https://doi.org/10.1093/oxfordhb/9780198733522.013.22>
- Markauskaite, L., & Goodyear, P. (2017). *Epistemic fluency and professional education: Innovation, knowledgeable action and actionable knowledge* (1st ed.). Springer. <https://doi.org/10.1007/978-94-007-4369-4>
- Marton, F. (1981). Phenomenography-describing conceptions of the world around us. *Instructional Science*, 10(2), 177–200. <https://doi.org/10.1007/BF00132516>
- Marton, F. (1986). Phenomenography: A research approach to investigating different understandings of reality. *Journal of Thought*, 21(3), 28–49. Retrieved July 29, 2024, from <http://www.jstor.org/stable/42589189>
- Marton, F., & Booth, S. (1997). *Learning and awareness*. Lawrence Erlbaum Associates.
- Millar, V. (2016). Interdisciplinary curriculum reform in the changing university. *Teaching in Higher Education*, 21(4), 471–483. <https://doi.org/10.1080/13562517.2016.1155549>
- Moore, T., & Morton, J. (2017). The myth of job readiness? Written communication, employability, and the “skills gap” in higher education. *Studies in Higher Education*, 42(3), 591–609. <https://doi.org/10.1080/03075079.2015.1067602>
- Nersessian, N. J. (2022). *Interdisciplinarity in the making: Models and methods in frontier science*. MIT Press.
- OECD. (2023). OECD skills outlook 2023: Skills for a resilient green and digital transition. *OECD Publishing*. <https://doi.org/10.1787/27452f29-en>
- Øland, T., Sauzet, S., Ryberg, M. L., & Lindvig, K. (2022). Configurations of interdisciplinarity within education: Danish experiences in a global educational space. *Routledge*. <https://doi.org/10.4324/9781003083245>
- Ripley, D., Markauskaite, L., & Goodyear, P. (2024). A phenomenographic exploration of course leaders’ understandings of interdisciplinarity. *Studies in Higher Education*, 49(11), 2208–2221. <https://doi.org/10.1080/03075079.2023.2293932>
- Spelt, E. J. H., Biemans, H. J. A., Tobi, H., Luning, P. A., & Mulder, M. (2009). Teaching and learning in interdisciplinary higher education: A systematic review. *Educational Psychology Review*, 21(4), 365–378. <https://doi.org/10.1007/s10648-009-9113-z>
- Tight, M. (2016). Phenomenography: The development and application of an innovative research design in higher education research. *International Journal of Social Research Methodology*, 19(3), 319–338. <https://doi.org/10.1080/13645579.2015.1010284>

Publisher’s Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Chapter 6: Variation in Approaches to Interdisciplinary Teaching and Learning: A Phenomenographic Investigation

Dwayne Ripley, Lina Markauskaite & Peter Goodyear.

Submitted to Teaching in Higher Education.

Now that variations in understandings of interdisciplinarity and conceptions of the purpose of interdisciplinary education have been established (Chapters 4 and 5), this article investigates variation in approaches to interdisciplinary teaching and learning in course designs.

Approaches to teaching and learning in course designs (Chapter 6) are situated within the wider context of design processes (Chapter 7) and the institutional environment for design (Chapter 8). Simultaneously, these approaches to interdisciplinary teaching and learning are interrelated with how course leaders understand interdisciplinarity and how they conceive of its purpose (see Figure 2.1).

This chapter is written as a journal article and has been submitted to Teaching in Higher Education. It may change based on revisions suggested by reviewers as part of the publication process.

For this article, I conducted data collection, data analysis, and the original draft preparation and revisions based on feedback from both supervisors and from two anonymous peer reviewers. Lina Markauskaite was responsible for reviewing and editing multiple drafts of the paper and conducting data analysis. My contribution to the paper is estimated at 75% and my supervisors at 25%.

Variation in Approaches to Interdisciplinary Teaching and Learning: A Phenomenographic Investigation

Abstract

Approaches to teaching and learning can play a critical role in higher education, but they have rarely been investigated in the context of interdisciplinary courses. This study uses phenomenographic interviews to address the question: *How do leaders of interdisciplinary courses approach teaching and learning in the design of their courses?* Analysis of the interviews shows that course leaders approach interdisciplinary teaching and learning in four qualitatively different ways, advancing in complexity. They focus on: (A) experience; (B) autonomy; (C) inquiry; and (D) epistemic agency. Comparable phenomenographic research in disciplinary settings reports approaches that advance from being teacher-centred, to student-centred. Our research reports approaches that advance from being centred on students' experiences of teamwork and autonomy to approaches that centre on students' engagement in knowledge-creating practices. In contrast to previous research in disciplinary contexts, these more sophisticated and expansive approaches to interdisciplinary teaching also include explicit teaching and scaffolding strategies.

Keywords: Approaches to teaching and learning, interdisciplinary education, educational design, phenomenography, epistemic agency

Introduction

There is an increased emphasis on interdisciplinary teaching and learning in higher education, aiming to prepare students for a changing world (Lyall et al., 2016). This includes preparing students for complex and uncertain future workplaces, working with rapid technological change, and addressing broader social, economic, and environmental challenges.

Interdisciplinary courses can serve different purposes (Lindvig, 2023) and develop different student capabilities (Lindvig & Ulriksen, 2019). Course leaders also often have significant

autonomy to make pedagogical decisions (Lyall et al., 2016). Unsurprisingly, the literature on interdisciplinary education suggests a great deal of variation in aims and methods (DeZure, 2017; Klein 2005). However, there has been relatively little systematic empirical research into approaches to interdisciplinary teaching and learning.

This contrasts with research on approaches to teaching and learning in the disciplines, which is now a well-established area of study, generating a number of consistent findings (Lindblom-Ylänne et al., 2006; Prosser & Trigwell, 1997, 2014; Trigwell & Prosser, 1991, 2020). In this paper, we build upon this tradition of discipline-based phenomenographic research to address the following question:

How do course leaders approach interdisciplinary teaching and learning when designing interdisciplinary courses?

Literature review

Disciplinary Approaches to Teaching and Learning

We use the term *approaches* to refer to how people go about something (Marton & Booth, 1997), and we use the terms *teaching and learning* together to show that teaching and learning are fundamentally related (Prosser & Trigwell, 1999). Phenomenographic studies that have investigated approaches to teaching and learning in disciplinary contexts commonly show a spectrum of approaches, advancing from teacher-centred to student-centred approaches (Lindblom-Ylänne et al., 2006; Prosser & Trigwell, 1997, 2014; Trigwell & Prosser, 1991, 2020). For instance, Prosser and Trigwell (2014) identify a range of approaches used in first-year courses, starting from a focus on transmitting information and advancing to helping students acquire, develop and change their conceptions. Teachers' approaches to teaching also influence students' approaches to learning (Trigwell & Prosser, 2020). Other studies have emphasised the importance of context. Trigwell and Prosser (1991)

identified the relationship between students' perceptions of their learning environment and how they approach learning. Prosser and Trigwell (1997) also reported on teachers' perceptions of their environments in how they approach their teaching. In both studies, a greater awareness of context was associated with deeper approaches to both learning and teaching. Lindblom-Ylänne et al. (2006) further reported that teachers who experience a variety of contexts may approach teaching differently depending upon the context. This is important to the study of approaches to interdisciplinary teaching and learning because, as Sauzet (2023) argues, these approaches may be influenced by local teaching and learning practices.

Interdisciplinary teaching and learning

The phenomenographic literature on variations in approaches to teaching and learning does not extend to interdisciplinary contexts. However, our review of other literature on interdisciplinary education reveals accounts of four common, interrelated approaches to interdisciplinary teaching and learning: problem-centred, experiential, integrative, and knowledge-creation approaches. This section briefly explains each, identifying the roles associated with teachers and learners, and mentioning salient critiques.

First, a *problem-centred* approach to interdisciplinary teaching and learning positions students as the creators of solutions, with teachers facilitating their efforts while withholding solutions and conclusive answers from them (Stentoft, 2017). This is often aligned with a focus on responding to society's 'grand challenges' (Sauzet, 2023). However, problem-centred approaches have been critiqued for not sufficiently developing students' foundations for working with knowledge, leaving them ill-prepared to respond to grand challenges (Millar, 2016).

Second, an *experiential* approach to interdisciplinary teaching and learning engages students with real-world complexities in interdisciplinary problem-solving, with different levels of structure and guidance provided by teachers (DeZure, 2017). In this approach, students learn through processes of self-reflection on their experiences (Stentoft, 2019). However, in disciplinary settings, it has been shown that teaching that is centred on students' self-reflection, but which offers minimal guidance can be less effective than teaching approaches that employ explicit instruction (Clark et al., 2012). However, greater attention to explicit strategies for developing students' capabilities for knowledge work in interdisciplinary teaching and learning are required (Boon et al, 2019; Boon & Van Baalen, 2019; Millar, 2016).

Third, an *integrative* approach to interdisciplinary teaching and learning involves preparing students to work with knowledge, methods, and tools from different disciplines by synthesising “two or more disciplinary insights — drawn from different perspectives — into new knowledge” (Menken and Keesstra, 2016, p. 42). Lindvig and Ulriksen (2019) offer three metaphors to help identify the type of interdisciplinary integration that is explicitly or implicitly taught: (1) pearls on a string—teaching of different disciplinary elements sequentially, (2) the zipper—different disciplinary elements are presented separately, and students draw them together, and (3) the snowflake—disciplinary elements are organised around a central problem. Nikitina (2006) offers three alternative ways to teach integration, including (1) contextualising, (2) conceptualising, and (3) problem-centring – each of which focuses on a different type of student inquiry. Whichever version of integration is adopted, its salient features, strengths and weaknesses should be made explicit to students (Lindvig & Ulriksen, 2019). That said, students must have an awareness of how knowledge is created for integrative learning to work (Boon and Van Baalen, 2019; Boon et al., 2019), yet disciplinary

expertise and understanding of knowledge creation practices are rarely well-developed in undergraduate students.

Fourth, a *knowledge creation* approach involves students' collaborative learning centred on the creation of knowledge objects (Muukkonen & Kajamaa, 2024; Paavola & Hakkarainen, 2005). A knowledge creation approach has significant potential for interdisciplinary teaching and learning. However, it has been argued that the approach often fail to pay explicit attention to the development of students' epistemic capabilities – capabilities needed for creating and validating knowledge (Markauskaite, 2020). Further, recent research has shown that the role technology plays in students' knowledge creation activities is also poorly understood (Korseberg & Stalheim, 2024).

Overall, a common theme identified in the critiques of these four overarching approaches is the limited attention that is given to the actual practices of knowledge work in interdisciplinary teaching and learning. Lindvig and Ulriksen (2019) show that many interdisciplinary teachers conceive of students' experiences of working together in interdisciplinary teams as supporting students' development of interdisciplinary capabilities, while others conceive of the development of students' interdisciplinary capabilities as requiring students to know how to work with different ways of creating knowledge (Boon et al., 2019; Markauskaite, 2020; Millar, 2016). These two views echo Jensen et al.'s (2019) conclusions that interdisciplinarity learning can be conceptualised in one of two ways; “through the characteristics of the people involved, or as the way knowledge is produced and handled in the learning process” (p. 10). How these conceptions of interdisciplinary learning relate to course leaders' approaches to interdisciplinary teaching and learning is, as yet only poorly understood.

Methodology

Our study takes a phenomenographic approach to investigate and map out how a phenomenon is collectively experienced (Åkerlind, 2008). This methodology has been used for some decades now, especially in research on teaching and learning in higher education (Tight, 2016; Trigwell & Prosser, 2020). The main findings from our research, as with many other phenomenographic studies, are organised as an ‘outcome space’: a representation of the variation in qualitatively different ways that course leaders approach interdisciplinary teaching and learning in their course designs.

Participants

Our study was conducted at a large, research-intensive Australian university. The protocol for the study was approved by The University of Sydney Human Research Ethics Committee (approval #2020/668). We conducted interviews with 23 academics who played a leading or substantial role in the conceptualisation, creation, revision, or implementation of interdisciplinary courses. For simplicity, we refer to them as *course leaders*. We identified participants by first locating courses in the university that were explicitly interdisciplinary. To be considered ‘interdisciplinary’, a course needed to fulfil three requirements: (1) the course description had to include the word ‘interdisciplinary’ or other comparable terms such as ‘multidisciplinary’ or ‘transdisciplinary’; (2) the course needed to have a collaborative student project component, and (3) projects needed to involve students from two or more different disciplinary backgrounds. We employed a maximum variation technique to identify, contact and interview 23 participants (course leaders) from across the university’s main discipline areas and organisational structures (Bowden & Green, 2005).

The study sample included twelve female and eleven male participants, with twelve participants holding lecturer-level positions (Lecturer or Senior Lecturer) and eleven holding professorial-level positions (Associate Professor or Professor). Six participants had

disciplinary backgrounds in the fields of medicine and health; five in the arts, humanities, and social sciences; four in business and law; four in engineering and design, and four in the sciences. Further background information can be found in Table 1. Of the courses that participants were associated with, all were available to undergraduate students and six were available to postgraduate students as well.

Data Collection

We conducted semi-structured interviews using videoconferencing software, recording both audio and video. The duration of the interviews ranged from 50 to 90 minutes. We adhered to a systematic procedure that involved asking the course leaders about their history and expertise in educational design, professional positions, approaches to interdisciplinary teaching and learning, and other experiences related to the interdisciplinary course. To explore participants' approaches to interdisciplinary teaching and learning in more detail, we used the Activity-Centred Analysis and Design wireframe (Goodyear et al., 2021) as a heuristic device to formulate follow-up questions. That is, we asked participants about three fundamental kinds of design considerations: epistemic (tasks, knowledge, pedagogy, etc.); social (roles, division of labour, etc.) and set (material and digital arrangements, learning spaces, tools, etc).

Table 6.1

Profiles of study participants

Participant ID	Academic level	Years in academia	Disciplinary area	Years leading interdisciplinary courses
1	Professor	16+	Arts, Humanities and Social Sciences	3
2	Lecturer	6–10	Sciences	2
3	Lecturer	0–5	Business and Law	2

4	Lecturer	11–15	Medicine and Health	4
5	Lecturer	0–5	Engineering and Design	2
6	Lecturer	6–10	Business and Law	3
7	Lecturer	6–10	Engineering and Design	2
8	Professor	11–15	Sciences	2
9	Professor	11–15	Engineering and Design	6
10	Professor	11–15	Medicine and Health	3
11	Lecturer	11–15	Business and Law	3
12	Professor	16+	Arts, Humanities and Social Sciences	4
13	Professor	16+	Medicine and Health	5
14	Lecturer	11–15	Medicine and Health	3
15	Professor	11–15	Engineering and Design	5
16	Lecturer	6–10	Arts, Humanities and Social Sciences	1
17	Lecturer	16+	Arts, Humanities and Social Sciences	4
18	Professor	16+	Medicine and Health	5
19	Lecturer	0–5	Business and Law	2
20	Lecturer	16+	Sciences	4
21	Professor	16+	Sciences	4
22	Professor	16+	Arts, Humanities and Social Sciences	7
23	Professor	16+	Medicine and Health	7

Data Analysis

In the analysis for this paper, we focussed on the course leaders' descriptions of approaches to interdisciplinary teaching and learning in their course designs. We analysed interview data using phenomenographic techniques (Åkerlind, 2012; Marton, 1986), aiming to create a phenomenographic outcome space consisting of *categories of description* (what the course leaders focused on when describing their approaches to teaching and learning) as well as *dimensions of variation* (illustrating the relationships between the categories). These categories and dimensions, when taken together, constitute a framework that delineates diverse approaches and demonstrates their logical interconnections.

We developed the categories of description and the dimensions of variation through an iterative process of sorting and identifying similarities and variations in the meanings of statements made by the course leaders. The first two authors worked together to examine and

refine the interim results, looping around several times to create a well-organised and defensible outcome space.

Following established methods of reporting the results of phenomenographic research, we present the outcome space in Table 2. The first part of the Outcomes section, below, provides an explanation of each of the four categories of description shown as the columns in Table 2. These explanatory passages include *illustrative* quotations from participants. We have tagged each quotation with an anonymising participant identification number (e.g., P7). In the quotations, ellipses are used to show where we have removed text that is not directly relevant to the research question. Italics are used to emphasise text of special relevance to the category concerned. Where necessary, brackets are used to identify an object referred to in a quote.

Outcomes

Course leaders described their approaches to teaching and learning in four qualitatively different ways. We have labelled these: (A) experience-centred—students getting experiences of working in teams; (B) autonomy-centred—students exercising autonomy; (C) inquiry-centred—students designing and managing processes of inquiry; and (D) epistemic agency-centred—students developing the capabilities for working with knowledge.

The four categories of description differ across six dimensions, covering social, epistemic and physical aspects of educational design. Two dimensions focus on *social* aspects: (1) the roles of teachers and (2) the roles of students. Two dimensions focus on epistemic aspects: (3) students' knowledge needs and (4) pedagogical strategies. Two dimensions focus on physical aspects: (5) technology use and (6) physical (learning/working) spaces.

The outcome space is presented in Table 2. It is organised hierarchically, ranging from less elaborate to more elaborate ways of experiencing a phenomenon, emphasising what course leaders focus upon in each category. The shaded areas of the outcome space represent the social, epistemic, and set aspects that course leaders were strategic about in their designs. The outcome space shows the relationships between the different categories, not only the differences between them (Åkerlind, 2024). It presents how the four ways course leaders approach interdisciplinary teaching and learning across six different dimensions of experience.

Category A: experience-centred

In Category A, course leaders described their approaches to interdisciplinary teaching and learning in their course designs as centred on designing for students to experience working in interdisciplinary teams. They portrayed the role of teachers as designing interdisciplinary team experiences, including team composition and set activities in advance for students.

We form teams mixing students from different majors. (P1)

What we built was a teaching environment. We curated a series of experiences for them. (P14)

They expressed the role of students as learning through participation and reflection on the experiences that teachers had set up for them.

It's experiential learning. I'm just wondering whether interdisciplinary theory really needs to be explicit. (P20)

A lot of it was self-reflection by the students. (P13)

Table 6.2

Outcome space: Course leaders' approaches to interdisciplinary teaching and learning in course designs

Categories Dimensions of variation	Category A Experience-centred	Category B Autonomy-centred	Category C Inquiry-centred	Category D Epistemic agency-centred	
1. Roles of teachers	To configure environment and facilitate students' interdisciplinary teamwork experiences	To give students control over their learning	To teach students how to conduct inquiry, and how to set up teamwork processes	To develop students' epistemic agency	Social aspects
2. Roles of learners	To participate in and reflect on interdisciplinary experiences	To collaborate and exercise autonomy	To design and conduct inquiry	To learn to engage in team-based interdisciplinary knowledge practices	
3. Student needs	To experience working in interdisciplinary teams	To envision and define projects	To develop research capabilities	To develop disciplinary expertise and epistemological awareness	Epistemic aspects
4. Pedagogical strategies	Experiential learning including student self-reflection	Grounded learning – teachers offer guidance following student attempts at project work	Expert guidance throughout the inquiry process	Explicit teaching to form a foundation for epistemic work	
5. Technology use	Teachers choose technologies to facilitate students' social interactions	Students choose technologies to support teamwork	Teachers present technology options to support students' inquiry, but students choose	Teachers choose innovative technologies for students' design and collaborative work	Set aspects
6. Physical spaces	Regular classrooms	Students preferably learn in-person over remotely and focus on co-creating objects	Students are exposed to different disciplinary workspaces but do not work in them	Students work in spaces designed to support interdisciplinary knowledge practices	

I am *not trying to design interdisciplinary courses*. I'm trying to do *student-focused education*. (P22)

Students really like interacting with students from different faculties from very different backgrounds. I think they really find some value in that, and that translates into a real *sense of interdisciplinarity*. (P20)

In line with the students' roles, pedagogical strategies emphasised experiential learning with a focus on students' individual reflection on their experiences.

This course was conceived of as having a *strong experiential learning experience (sic)*. (P1)

Reflective practice was a part of it. (P23)

Technologies were configured in advance by teachers to enable and support student interactions.

We set up groups on Canvas, to try to get them at least to *initiate contact* with each other, and that worked in most cases. (P4)

They viewed the interdisciplinarity environment in relation to social interactions, not material or physical aspects of the environment.

We're not spending a great deal of time explicitly teaching them how to work in an interdisciplinary environment; *they are working in an interdisciplinary environment in the classroom*. (P9)

Overall, in the experience category, the teaching and learning approach was characterised as exposing students to different disciplinary perspectives through participation in interdisciplinary teams and teamwork. However, interdisciplinarity was expressed in relation to the disciplinary composition of student teams rather than an emphasis on how students should work together in interdisciplinary teams, in interdisciplinary ways. Approaches to teaching and learning centred on students' participation and social interactions. Teachers were described as facilitators supporting student-centred learning.

Category B: Autonomy-centred

In Category B, course leaders' approaches to teaching and learning were centred on facilitating students' autonomy in creative project work, with emphasis placed upon the outcomes or products of their interdisciplinary teamwork.

The role of the teacher was described as a facilitator for students' interdisciplinary teamwork, helping them to create products or solutions.

[for teachers] *it's about facilitating*, for [students] it's about creating. (P14)

Getting students to really *reflect on the product of the project*. (P20)

Learners were given autonomy to create their teams and project focus based on their interests and given autonomy to manage their teamwork processes.

Students pitch themselves to their peers and they naturally come together *according to interests*. (P3)

It's that conceptualization of the mission, *the vision of the project*, and then followed by simple *project management* – “who's doing what, how are we bringing it together?” (P6)

However, course leaders highlighted the difficulties students faced when framing problems in interdisciplinary teamwork.

Students struggle to identify *their vision* for the team and their project. (P6)

Students have the agency to define their projects *with some sort of scaffolding required*, because they may not have that kind of understanding of the real world and work. (P16)

The pedagogical strategy focused on having students first attempt to work in their teams without guidance to ground their learning in experiences, followed by the teacher providing instruction to help consolidate their strategies and their learning.

An approach that I like with a lot of what I do, is *getting students to have a go* before I tell them how something *should be done*. (P5)

Allowing them to do whatever they wanted... and then having someone go okay, this is quite often how groups will work. (P14)

Technologies were chosen by students and based on students' preferences. They mainly included popular platforms that supported team communications.

I have come to realise that as a middle-aged person talking to a bunch of millennials that *you can suggest things, but you're much better off letting them work it out*. (P20)

That seems to be naturally *where the students want to go to*—to Facebook or WhatsApp or FaceTime or whatever. They seem to be the big three that they use. So, *I haven't tried to intervene in that*. (P3)

Course leaders described making use of existing, available physical spaces in the university set up to facilitate the work of small teams of students.

This class is supposed to be an in-person class, where *we could use those rooms that have the four student pods available*. (P22)

In the autonomy category, course leaders' approaches centred on giving students freedom and control over decisions in their project work. Learning centred on students' choice over who they worked with, what they worked on, and how they managed their teamwork. Teachers scaffolded students, acting as facilitators. This approach emphasised students' power to co-create products and solutions. However, course leaders described creation in relation to students' preferences and interests, rather than how different disciplines work together. Although this was often referred to by course leaders as 'agency', their descriptions were largely characteristic of 'autonomy'; students had freedom to choose but may not have developed the required capabilities to make informed decisions, especially in relation to how to work with different disciplinary ways of framing problems and creating knowledge.

Category C: Inquiry-centred

In Category C, course leaders emphasised approaches centred on fostering students' capabilities to design and conduct inquiry. The role of the teacher was centred on developing students' capabilities to learn through creating knowledge, providing some explicit knowledge and scaffolding to inform students' decisions.

You're trying to *teach them how to learn*. (P18)

We *encourage them* to create groups with students from different backgrounds... We *tell students* that this would be really helpful. (P2)

The role of students was centred on developing their capability to establish processes for teamwork to enable them to strategically conduct inquiry.

Rather than just trying to come up with the best solution, what you should try to be doing is, as a student in these units, is *learning the process*. (P14)

Students lead the research phase at the beginning. Often that *involves primary research*. (P17)

Course leaders identified the need to develop students' research capabilities.

The students are at a point where *they haven't practiced research*, they haven't developed the idea of applying methodologies and where they [the methodologies] come from. (P20)

The first five weeks of the course are all about problem identification. The second part is all about problem-solving... so *it's an inquiry system*. (P2)

Course leaders' pedagogical strategies were centring on developing students' capabilities to design, conduct, and evaluate inquiry methods. Teachers led and scaffolded their critical reflection throughout the inquiry process, including reflection on their design of inquiry, the way they conducted inquiry, and the methods they used in inquiry. Whereas in Category B, the focus of the approach was on the product of teamwork, in Category C, teaching and

learning centred on the processes of teamwork and developing students' capabilities for designing inquiry.

We workshopped a mind mapping exercise where we said, "So what's your problem? Or what's your what's your research question? What are all the things that you would need to know to try and answer this question?" (P23)

In the *follow-up assignments*... they would be asked, "Were there any other methods that you would rather use but you couldn't because of this? Then if you were to use the other method, what would be the advantages or limitations?" (P2)

The technologies course leaders detailed were intended to support different ways of working in teams. Suitable technologies were suggested but students could choose technologies if they found them to be more suited to their project needs.

We offered Microsoft 365. I think *we offered* that as a space, because one group did a community survey. So, they wanted to put it online for people to be able to do online. I think they chose to use Google Forms or something that; *they decided* not to use the one that was offered by the university. (P12)

Course leaders outlined the intentional design of physical spaces for interdisciplinary learning intended to expose students to the places, spaces, and tools that different disciplines employ when conducting inquiry and creating knowledge. However, they identified that university policies did not always support this approach. Thus, students were exposed to the physical and material settings of other disciplines but could not directly engage in different disciplinary knowledge practices.

Students could actually move around between labs. That was the intention, and how it was designed... *However, [discipline A] students can't run experiments in [discipline B] labs* because they have no training... and that's a safety hazard. So, we also wanted to make sure that students who are not trained don't play with the instruments... For insurance purposes. (P8)

In the inquiry category, course leaders emphasised a more dynamic approach to interdisciplinary teaching and learning than we saw in categories A and B. It centred on

developing students' capabilities to conduct primary research and involved guidance and prompting students' critical reflection on their methodological choices and processes. Course leaders emphasised students developing their capabilities to design and conduct inquiry.

Category D: Epistemic agency-centred

In Category D, course leaders described their approaches as centred on introducing students to, and preparing them for, working with different disciplinary ways of creating and using knowledge: in other words, developing their epistemic agency. Course leaders explicitly introduced students to the epistemic challenges of interdisciplinary teamwork, so they (students) could be aware of, and learn to participate in, different knowledge practices.

Ultimately, *interdisciplinarity is not automatic...* What we found was that the physical space and the curriculum space may permit it, but *you still have to design for interdisciplinarity* (P23)

One fundamental idea of this [course] is to bring students from all parts of the faculties *in contact*, so that they, on the one hand, reflect on their discipline and on the other, *they actually find out about other disciplines, other epistemologies, other knowledge practices, other methodologies* (P1)

Course leaders stated the roles of students as expanding their epistemic and conceptual positions, developing their epistemic agency and to consider the mechanics of how to work with others in interdisciplinary teamwork.

Disciplines have their concrete and intangible and agreed ways of tackling things... A lot of the time that helps students look at a given thing and realise that perhaps the one way that they've been taught to do it, or *the way they've always done it isn't the only way*. (P5)

The first thing [for students to consider] is, "*How do we work together, how do we make sure everybody's heard, how do we develop trust*". (P14)

The development of a depth of students' disciplinary expertise was identified as a prerequisite for students to conduct interdisciplinary knowledge work. This involved first developing students' awareness of different knowledge cultures and practices, including their own.

Having worked with undergraduate students, they might be in their final year, but *I'm not sure we can even speak of interdisciplinary education just yet because they bring little disciplinary depth to their projects.* (P6)

They [students] don't have that disciplinary grounding we are assuming as a prerequisite. We're not developing it, except for reflection on an often *fairly naive perspective* on what that discipline is. (P20)

Pedagogical strategies were expressed as centred on introducing students to different areas and/or kinds of knowledge and different ways of working with knowledge. Part of this was explicitly introducing students to the meaning of interdisciplinarity, referencing key scholars on interdisciplinary research, and the potential for interdisciplinarity to address complex problems in society.

The first thing to do was... *enhance our students' interdisciplinary literacy.* (P23)

The topics that we tend to cover are things like, where do disciplines come from? *What does interdisciplinary mean?* So, what do we mean by interdisciplinarity versus multidisciplinary and what are the differences? So, we use for example, *readings from Menken and Kestra.* (P1)

Course leaders noted explicitly choosing novel technologies that supported students' collaboration in teams. Technologies were chosen because they were commonly used to support knowledge work in industry.

We used a tool called Balsamic for prototyping, then we changed it to something called Figma which is becoming *more popular*... Students can benefit from learning to use them. (P2)

I think it's really important from an institutional perspective, *to have some vision about how these various emerging technologies can actually be beneficial.* (P19)

Course leaders described making use of lab spaces that had been specially designed to facilitate interdisciplinary student learning—exposing students to different ways of creating and working with knowledge and offering experiences of observing and/or participating in different knowledge practices.

The lab space... had to be fit for purpose in teaching students of science but at the same time, the *vision was to enable interdisciplinarity, through increased visibility and shared practices*. By virtue of sharing the spaces and *making them available to other ways of doing and knowing... the space facilitated interdisciplinarity*. (P23)

In the epistemic agency category, course leaders emphasised explicitly introducing students to different ways of working with knowledge. They again portrayed a dynamic relationship between teaching and learning that was student-centred at times and (on the surface, at least) teacher-centred at others: involving explicit teaching of what course leaders deemed to be essential knowledge and skills, to support students' interdisciplinary ways of working when constructing knowledge.

Relationships between the categories

The six dimensions of variation in the outcome space (Table 2) present the structural aspects of course leaders' approaches to interdisciplinary teaching and learning. The shaded areas of the outcome space show the areas wherein course leaders emphasised their strategic awareness of different social, epistemic, and set aspects in their designs.

Advancing from Category A to Category D, the approach to interdisciplinary teaching and learning becomes more comprehensive and shows an increasing awareness of the social, pedagogical, and physical aspects of course designs. The differences and relationships between the categories become more explicit when examined through the dimensions of variation (that is, rows numbered 1–6 in Table 2).

Analysis of the *social aspects* of course designs shows that in Dimension 1, course leaders described the role of teachers being to facilitate students' learning in Categories A and B, and to be experts developing students' capabilities for working with knowledge in Categories C and D. In Dimension 2, course leaders described the role of students as centred on their experiences and their autonomy in creating products in Categories A and B respectively, and on designing and enacting processes of inquiry and on learning to work with knowledge practices in interdisciplinary ways in Categories C and D respectively. The social aspects advanced from centring on students' experiences and autonomy with teachers facilitating, in the first two categories (A & B), to centring on knowledge creation that included explicit guidance and scaffolding in the last two categories (C & D).

Analysis of the *epistemic aspects* of course designs shows that in Dimension 3, course leaders described a focus on what students do (experiences and identifying problems) in Categories A and B, whereas in Categories C and D, they described a focus on how students worked (conducting inquiry and working with different knowledge practices). In Dimension 4, they described facilitating students' project work experiences, and using the experiences to ground learning, in Categories A and B respectively. They addressed developing students' capabilities to design and conduct inquiry and to explicitly develop their awareness of epistemic aspects of interdisciplinary knowledge work in Categories C and D respectively. In the latter two categories, course leaders emphasised explicit teaching, strategic guidance, and critical reflection. Overall, course leaders described interdisciplinary teamwork in relation to the diversity of disciplines within student teams in Categories A and B, and in relation to knowledge and knowledge practices in Categories C and D.

Analysis of the *physical aspects* of course designs shows course leaders' increasing awareness of the material and digital in support of interdisciplinary student activity. In Dimension 5, *technology use*, course leaders described technology use as chosen by either

teachers or students, in Categories A and B. They described it as both supporting social interaction, as configured to project needs, in Category C, and as supporting collaborative design work, in Category D. In Dimension 6, *physical spaces*, approaches advanced from a lack of awareness of the role of settings in interdisciplinary learning—using existing disciplinary spaces for interdisciplinary teamwork (Categories A and B), to spaces being intentionally designed to give students exposure to, and experience of, interdisciplinary knowledge practices (in Categories C and D).

Discussion

The outcomes of this study show that course leaders approach interdisciplinary teaching and learning in four qualitatively different ways; two that are centred on students' experiences and autonomy and two that are centred on knowledge creation. Our outcome space shows the relationships between the four approaches and is ordered hierarchically, meaning that the categories are not mutually exclusive but become increasingly comprehensive advancing from Category A to D. The study makes three main contributions to our understanding of approaches to teaching and learning.

Prior studies of approaches to teaching and learning in disciplinary contexts have shown a spectrum of approaches, advancing from teacher-centred approaches to more inclusive and comprehensive student-centred approaches (Lindblom-Ylänne et al., 2006; Trigwell & Prosser, 1996). Our research reports that the less comprehensive approaches (A and B) align with student-centred approaches, while the more comprehensive approaches (C and D) are primarily centred on knowledge practices. These latter approaches extend on the approaches in Categories A and B to further include aspects of explicit instruction and strategic scaffolding. In earlier studies of approaches to teaching and learning in disciplinary contexts, explicit instruction and scaffolding were associated with less comprehensive

teacher-centred approaches. Our research, explicit instruction and scaffolding were associated with more comprehensive approaches that centre on knowledge practices. In other words, teachers' approaches to supporting the development of students' research and knowledge work capabilities included making use of explicit instruction and scaffolding strategies but were not reliant upon them alone. It may be that shared attention to the complexity and challenges of interdisciplinary knowledge work prompts episodes of explicit instruction.

Secondly, course leaders emphasised the social and pedagogical aspects of their approaches in all categories. However, it was only in Categories C and D that we found course leaders evidencing a strategic awareness of, and designs for, technologies and physical spaces to support the development of students' research capabilities and epistemic agency for interdisciplinary knowledge work. In disciplinary settings, Lindblom-Ylänne et al., (2006) argued that teachers adapted their approaches to the contexts they inhabited. We found that, in Categories A and B, course leaders used the classrooms, remote learning tools and other existing, known technologies because they were readily available and familiar to them: they adapted their approaches to existing circumstances. However, in Categories C and D, course leaders actively configured interdisciplinary spaces and technologies that were suited to conducting research, or facilitating collaborative design, to suit their strategic approaches. In Categories A and B, course leaders adapted their approaches to their context; in Categories C and D, course leaders (re)designed their contexts to suit their preferred approaches.

Thirdly, our research underlines the importance of being explicit about conceptions and assumptions regarding how interdisciplinary teaching and learning happens. Our outcomes support the argument made by Jensen et al. (2016) that interdisciplinary learning can be understood in relation to the disciplinary composition of student teams (Categories A and B), or in relation to ways of working with knowledge (Categories C and D). Our outcome space shows the variation in approaches advancing from a focus on *who* works together to

how students from different disciplinary backgrounds work together. This is important because *how* complex problems are framed and addressed are interdependent (Markauskaite & Goodyear, 2017). When interdisciplinarity is conceived of as a matter of team composition, several important things may be obscured. These include the processes used to co-construct the products of interdisciplinary work (solutions) but also the more consequential processes involved in framing and deciding how to address the problem.

Conclusions

In this study, we have shown course leaders approaching interdisciplinary teaching and learning in four qualitatively different ways, including two approaches that emphasise students' experiences and autonomy, and two approaches that focus on the explicit development of students' research capabilities and epistemic agency. The approaches centred on knowledge practices were inclusive of the approaches that centred on students' experiences and autonomy, adding a focus on the mechanics of knowledge production. The approaches centred on knowledge practices are associated with a greater awareness of the complexities and challenges of interdisciplinary knowledge work.

The study's outcomes show the importance of being explicit about the focus of interdisciplinary courses. Interdisciplinary learning was conceived of and approached in two distinct ways – in relation to team composition and in relation to ways of working with knowledge – but the differences in conceptions were rarely articulated. Our outcomes can raise awareness of these two ways of conceiving of interdisciplinary learning, and support reflection on ways of approaching interdisciplinary teaching and learning in educational design work.

Our outcomes further show a spectrum of ways that technologies were used in approaches to interdisciplinary teaching and learning, advancing from a focus on students' interactions and communications to inquiry processes, and collaborative design work. Our outcomes show that the most comprehensive approach to technology centred on tools that are commonly used in industry. However, little was said about the configuration of multiple technologies for different purposes for teaching and learning (or knowledge work). It is important that teachers find ways of moving beyond the promotion of individual technologies and become more adept at matching (and helping students match) sets of tools to typical sequences of tasks: an important aspect of working with different knowledge practices (Korseberg and Stalheim, 2024). Further research on how technologies are chosen and configured in approaches to interdisciplinary teaching and learning approaches is needed.

This study contributes to research on interdisciplinary education by presenting a spectrum of approaches to interdisciplinary teaching and learning at one Australian university. The outcome space presents a spectrum from less to more comprehensive ways of approaching interdisciplinary teaching and learning in course designs. These outcomes do not identify any 'right' way of approaching interdisciplinary teaching and learning but instead contribute to an expanded awareness of design considerations for course leaders to draw upon when designing for interdisciplinary teaching and learning.

Acknowledgments

This research was partly funded by the Australian Research Council through Discovery Project grant DP200100376 (Developing interdisciplinary expertise in universities).

Declarations

The authors report there are no competing interests to declare.

Data availability statement

The participants of this study did not give written consent for their data to be shared publicly, so due to the sensitive nature of the research, supporting data is not available.

References

- Åkerlind, G. S. (2008). A phenomenographic approach to developing academics' understanding of the nature of teaching and learning. *Teaching in Higher Education*, 13(6), 633–644. <https://doi.org/10.1080/13562510802452350>
- Åkerlind, G. S. (2012). Variation and commonality in phenomenographic research methods. *Higher Education Research and Development*, 31(1), 115–127. <https://doi.org/10.1080/07294360.2011.642845>
- Åkerlind, G. S. (2024). Common misunderstandings of phenomenographic research in higher education. *Higher Education Research and Development*, 43(1), 1–16. <https://doi.org/10.1080/07294360.2023.2218804>
- Boon, M., & Van Baalen, S. (2019). Epistemology for interdisciplinary research – Shifting philosophical paradigms of science. *European Journal for Philosophy of Science*, 9(1), 16. <https://doi.org/10.1007/s13194-018-0242-4>
- Boon, M., van Baalen, S., & Groenier, M. (2019). Interdisciplinary expertise in medical practice: Challenges of using and producing knowledge in complex problem-solving. *Medical Teacher*, 41(6), 668–677. <https://doi.org/10.1080/0142159X.2018.1544417>
- Bowden, J. A., & Green, P. (Eds.). (2005). *Doing developmental phenomenography*. RMIT University Press.
- Clark, R. E., Kirschner, P. A., & Sweller, J. (2012). Putting students on the path to learning: The case for fully guided instruction. *American Educator*, 36(1), 5–11.
- DeZure, D. (2017). Interdisciplinary pedagogies in higher education. In R. Frodeman (Ed.), *The Oxford handbook of interdisciplinarity* (2nd ed., pp.558–572). Oxford University Press. <https://doi.org/10.1093/oxfordhb/9780198733522.013.45>

- 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>
- Jensen, A. A., Ravn, O., & Stentoft, D. (2019). Problem-based projects, learning and Interdisciplinarity in higher education. In A. Jensen, D. Stentoft, & O. Ravn (Eds.), *Interdisciplinarity and problem-based learning in higher education*. (pp. 9–19). Springer. https://doi.org/10.1007/978-3-030-18842-9_2
- Klein, J. T. (2005). Integrative learning and interdisciplinary studies. *Peer Review*, 7(4), 8–10.
- Korseberg, L., & Stalheim, O.R. (2024). The role of digital technology in facilitating epistemic fluency in professional education. *Professional Development in Education*, 1–17. <https://doi.org/10.1080/19415257.2024.2421489>
- Lindblom-Ylänne, S., Trigwell, K., Nevgi, A., & Ashwin, P. (2006). How approaches to teaching are affected by discipline and teaching context. *Studies in Higher Education*, 31(3), 285–298. <https://doi.org/10.1080/03075070600680539>
- Lindvig, K. (2023). Loud and soft voices of interdisciplinarity in higher education. In T. Øland, S. Sauzet, M. L. Ryberg, & K. Lindvig (Eds.), *Configurations of interdisciplinarity within education: Danish experiences in a global educational space* (pp. 94–118). Routledge. <https://doi.org/10.4324/9781003083245-5>
- Lyall, C., Meagher, L., Bandola, J., & Kettle, A. (2016). *Interdisciplinary provision in higher education: Current and future challenges*. Higher Education Academy.
<https://documents.advance-he.ac.uk/download/file/document/4604>
- Markauskaite, L. (2020). Commentary: Learning for knowledge work practices in the wild. *Research Papers in Education*, 35(1), 105–115.
<https://doi.org/10.1080/02671522.2019.1677762>
- Markauskaite, L., & Goodyear, P. (2017). *Epistemic fluency and professional education innovation, knowledgeable action and actionable knowledge*. Springer Netherlands.
<https://doi.org/10.1007/978-94-007-4369-4>
- Marton, F. (1986). Phenomenography—A research approach to investigating different understandings of reality. *Journal of Thought*, 21(3), 28–49.
- Marton, F., & Booth, S. (1997). *Learning and awareness*. Lawrence Erlbaum.

- Menken, S., & Keestra, M. (2016). *An introduction to interdisciplinary research: Theory and practice* (Vol. 2). Amsterdam University Press.
- Millar, V. (2016). Interdisciplinary curriculum reform in the changing university. *Teaching in Higher Education*, 21(4), 471–483. <https://doi.org/10.1080/13562517.2016.1155549>
- Muukkonen, H., & Kajamaa, A. (2024). Knowledge objects and knowledge practices in interdisciplinary learning: Example of an organization simulation in higher education. *The Journal of the Learning Sciences*, 33(2), 365–404. <https://doi.org/10.1080/10508406.2024.2344794>
- Nikitina, S. (2006). Three strategies for interdisciplinary teaching: Contextualizing, conceptualizing, and problem-centring. *Journal of Curriculum Studies*, 38(3), 251–271. <https://doi.org/10.1080/00220270500422632>
- Paavola, S., & Hakkarainen, K. (2005). The Knowledge Creation Metaphor: An Emergent Epistemological Approach to Learning. *Science & Education*, 14(6), 535–557. <https://doi.org/10.1007/s11191-004-5157-0>
- Prosser, M., & Trigwell, K. (1997). Relations between perceptions of the teaching environment and approaches to teaching. *The British Journal of Educational Psychology*, 67(1), 25–35. <https://doi.org/10.1111/j.2044-8279.1997.tb01224.x>
- Prosser, M., & Trigwell, K. (1999). Relational perspectives on higher education teaching and learning in the sciences. *Studies in Science Education*, 33(1), 31–60. <https://doi.org/10.1080/03057269908560135>
- Prosser, M., & Trigwell, K. (2014). Qualitative variation in approaches to university teaching and learning in large first-year classes. *Higher Education*, 67(6), 783–795. <https://doi.org/10.1007/s10734-013-9690-0>
- Sauzet, S. (2023). Interdisciplinarity in the University Colleges: Versions of interprofessional responsibility. In Øland, T., Sauzet, S., Ryberg, M.L., & Lindvig, K. (Eds.), *Configurations of interdisciplinarity within education: Danish experiences in a global educational space* (Vol. 1, pp. 69–93). Routledge. <https://doi.org/10.4324/9781003083245-4>
- Stentoft, D. (2017). From saying to doing interdisciplinary learning: Is problem-based learning the answer? *Active Learning in Higher Education*, 18(1), 51–61. <https://doi.org/10.1177/1469787417693510>

- Stentoft, D. (2019). Three challenges for new students facing problem-based and interdisciplinary learning. In *Interdisciplinarity and problem-based learning in higher education* (pp. 49–60). Springer International Publishing. https://doi.org/10.1007/978-3-030-18842-9_5
- Tight, M. (2016). Phenomenography: The development and application of an innovative research design in higher education research. *International Journal of Social Research Methodology*, 19(3), 319–338. <https://doi.org/10.1080/13645579.2015.1010284>
- Trigwell, K., & Prosser, M. (1991). Improving the quality of student learning: The influence of learning context and student approaches to learning on learning outcomes. *Higher Education*, 22(3), 251–266. <https://doi.org/10.1007/BF00132290>
- Trigwell, K., & Prosser, M. (2020). *Exploring university teaching and learning: Experience and context*. Palgrave Macmillan. <https://doi.org/10.1007/978-3-030-50830-2>
- Vienni Baptista, B., Fletcher, I., Maryl, M., Wciślik, P., Buchner, A., Lyall, C., Spaapen, J., & Pohl, C. (2020). Final report on understandings of interdisciplinary and transdisciplinary research and factors of success and failure. *Zenodo*. <https://doi.org/10.5281/zenodo.3824839>

Chapter 7: Interdisciplinary Course Design Processes: A Phenomenographic Study of Course Leaders' Experiences

Dwayne Ripley, Lina Markauskaite & Peter Goodyear.

Submitted to Instructional Science.

This article investigates course leaders' experiences of designing for interdisciplinary teaching and learning at the meso level. The investigation of design processes is central to this thesis, as it generates insights into what course leaders actually do, recentring research from theoretical conjectures to the actualities of practice. How course leaders understand interdisciplinarity, conceive of the purpose of interdisciplinarity in education, and approach interdisciplinary teaching and learning in course designs are influence how course leaders experience design processes. Further, design processes are situated within institutional environments that can influence design processes. Once again, see Figure 2.1 to view how the chapters are interrelated.

This chapter is written as a journal article, but it has not yet been submitted to a journal. It will be revised and submitted for publication following the thesis examination.

For this article, I conducted data collection, data analysis, and the original draft preparation and revisions based on feedback from both supervisors and from two anonymous peer reviewers. Lina Markauskaite was responsible for reviewing and editing multiple drafts of the paper, and conducting data analysis, and Peter Goodyear was responsible for reviewing and editing drafts. My contribution to the paper is estimated at 75% and my supervisors at 25%.

Interdisciplinary Course Design Processes: A Phenomenographic Study of Course Leaders' Experiences

Abstract

The expansion of interdisciplinary courses in higher education has created an increase in the complexity, challenges, and demands placed upon the people responsible for creating and sustaining them. This expansion has created a demand for practical knowledge that can inform and guide educational design for interdisciplinary teaching and learning. This study answers the question: *How do course leaders experience educational design processes when developing interdisciplinary courses?* Results from phenomenographic interviews with 23 leaders of interdisciplinary courses reveal that course leaders experience design processes in four ways: (A) ad hoc and on-the-run; (B) modification; (C) dialogic co-creation; and (D) design as inquiry. In all four categories, course leaders describe their experiences of design processes as reliant upon collegial communities and networks of support. Advancing from Category A to D, there is significant consideration given to physical social aspects of design processes and an awareness of the importance of documenting and sharing the knowledge generated in design processes. The study's outcomes shed further light on the design processes that underlie interdisciplinary course creation, which could be used to inform locally appropriate design processes. Implications for the documentation and sharing of design knowledge generated in interdisciplinary course design processes are discussed.

Keywords: educational design, design knowledge, interdisciplinary teaching and learning, higher education, phenomenography

Introduction

The expansion of interdisciplinary courses and programmes in universities around the world has generated a demand to better understand how to design for interdisciplinary teaching and learning (DeZure, 2017). However, designing for interdisciplinary teaching and learning can

be challenging for the people who lead interdisciplinary courses. There can be increased complexity and significant challenges (Bopardikar, 2021). Further, interdisciplinary teaching and learning serves different purposes and aims to develop different student competencies (Lindvig & Ulriksen, 2019), so there is also significant variation in how interdisciplinary courses can be configured (Øland et al., 2023). Additionally, empirical studies on interdisciplinary teaching often ‘universalise’ findings and rarely present rich contextual accounts. This can impact the usefulness of the research (Lindvig & Ulriksen, 2019). Together, these conditions show that educational design for interdisciplinary teaching and learning can be significantly challenging for people developing and sustaining interdisciplinary courses in universities.

Leaders of interdisciplinary courses are often ill-prepared for designing interdisciplinary courses. McKenney et al. (2015) argue that “teacher education programmes devote relatively little time to developing expertise in the design of instruction, beyond lesson planning” (p. 181). Learning how to design, therefore, is often developed through individual experience and scholarship. However, this solitary approach can be unsustainable in the face of increased complexity and sophistication in planning for teaching and learning (Goodyear & Ellis, 2019). Interdisciplinary teaching and learning is not only challenging (Ashby & Exter, 2019) but also resource-intensive (Lyall et al., 2016), yet individual academics are commonly left with the sole responsibility for the creation of interdisciplinary courses in absences of sufficient support or resourcing (Lindvig et al., 2019). There is a need for research on the methods, tools, practices, and capabilities that are used in interdisciplinary educational design processes in local learning settings and how interdisciplinary course leaders experience their design processes. This can generate practical knowledge on designers’ needs and required capabilities and can help to develop "a richer understanding of

how design is actually accomplished" (Goodyear, 2018). This research can generate insight into how design work is accomplished, research that is useful to other designers.

This article reports on a phenomenographic study that investigates how academics who make substantial intellectual contributions to the design, redesign, and enactment of interdisciplinary courses (we refer to these academics as ‘course leaders’) experience interdisciplinary course design processes. We report on the variation in course leaders’ experiences and explore the relationships between different ways of experiencing design processes to answer the research question, *How do course leaders experience educational design processes when developing interdisciplinary courses?*

We use the term ‘interdisciplinary’ to denote a focus on students from different disciplines working together with their own disciplinary and other knowledge cultures to co-create knowledge in service of addressing complex problems. Repko et al. (2017) define interdisciplinarity as “the study of a complex issue, problem, or question from the perspective of two or more disciplines by drawing on their insights and integrating them” (p. 108). However, Ripley et al. (2023) show that course leaders’ understandings of the term ‘interdisciplinary’ do not neatly align with the taxonomic definition. Vienni Baptista et al. (2020) also show that ‘interdisciplinarity’ is used more often than, and interchangeably with, the term ‘transdisciplinary’. Our use of the term ‘interdisciplinary’ is therefore inclusive of non-academic partners and knowledge cultures commonly denoted by the term ‘transdisciplinary’.

To situate our study, we first review the literature on educational design in higher education, then educational design specific to interdisciplinary teaching and learning. We then review the literature on design knowledge — practical knowledge that is useful to educational designers.

Design for Interdisciplinary Teaching and Learning

Limited attention has been given to the processes of educational design in higher education (Laurillard, 2012), despite the essential role that it plays in teaching and learning (Bennett et al., 2018). This is especially true when the design is being done for authentic rather than experimental purposes (Goodyear, 2015). There is a specific demand for research on design for interdisciplinary teaching and learning because it can be challenging and complex.

McKenney et al. (2015) argue that when the scope of design tasks increases, design processes demand increased collaboration by larger design teams. Unsurprisingly, designing for interdisciplinary teaching and learning is commonly described by practitioners as collaborative work (Ashby & Exter, 2019; Bopardikar et al., 2021). However, university leaders perceive individuals to be the drivers of interdisciplinary provision in universities, referring to them as ‘enterprising’ individuals and as ‘lone wolves’ (Lyll et al., 2016), despite the demanding collaborative work that is commonplace.

In universities, design rarely follows a linear sequence or systematic approaches (Bennett et al., 2017). Variation in design processes is the norm, not the exception. However, educational design processes are situated. Goodyear (2021) clarifies this, noting that "what teachers and teaching teams can do during a design activity is influenced, in subtle and powerful ways, by the social, physical, and epistemic constraints and affordances of the situation in which they are doing that work" (p. 244). Therefore, to effectively study design processes at a university, exploring the physical, social, and epistemic aspects of design processes is essential to identifying and exploring variation.

In higher education, practitioners’ knowledge about how to design is commonly developed intuitively through experience and remains largely unarticulated and unshared (McKenney et al., 2015). Goodyear (2018) argues that the learning that happens in educational design processes gets limited attention precisely because it is undocumented,

hard to share, and does not describe or articulate how design work is or should be done. To advance interdisciplinary education, it has been argued that the people who develop and sustain interdisciplinary teaching and learning should share their work (Lyall et al., 2016). Ellis and Goodyear (2019) argue for the need to research how design is accomplished to generate knowledge on design that is practically useful to practitioners. Goodyear et al. (2023) call this knowledge “tuned to the requirements of design work” (p. 65).

For design for interdisciplinary teaching and learning, Christensen and Markauskaite (2025) concluded from a systematic review of the literature that design knowledge is generated in two ways. First, through research-first approaches such as the contribution of refined design principles to facilitate collaboration for interdisciplinary teaching and learning (Cremers et al., 2017; Kidron & Kali, 2015), and second, through experience-first approaches such as Bopardikar et al. (2021), who reported on the design processes of an interdisciplinary design team, describing both designers’ rationales and activities to support other designers to learn from their experiences. This study aims to create further practically useful knowledge on course leaders’ experiences of design processes for interdisciplinary courses.

Studies of educational design in universities have commonly relied on interviews, experimental studio studies, and observational studies of discourse in design meetings (Goodyear, 2015), collective autoethnography (Bowers et al., 2021) and interpretive case studies (Bopardikar et al., 2021). This study, however, investigates variation in how course leaders experience design processes and therefore uses a phenomenographic approach.

Methodology

This article reports the outcomes from phenomenographic research investigating how leaders of interdisciplinary courses at a large, research-intensive Australian university experience

educational design processes. The study's protocol was approved by the Human Research Ethics Committee (approval #2020/668) at the University of Sydney.

Data Collection and Analysis

The research involved interviews with 23 academics (12 women and 11 men) who led or contributed significantly to the design, redesign, conceptualisation, or enactment of interdisciplinary courses. We call them 'course leaders', a term that represents the non-standard nature of the development of interdisciplinary courses that characterised the experiences documented in this study. Course leaders' backgrounds were diverse. The sample included 12 participants with lecturer-level positions (Lecturer or Senior Lecturer) and 11 participants with professorial-level positions (Associate Professor or Professor). Participants' disciplinary fields included medicine and health (6), the arts, humanities, and social sciences (5), business and law (4), engineering and design (4), and the sciences (4). Details can be found in Table 7.1. All participants led undergraduate courses; however, six of the courses were also open to postgraduate students.

Purposeful sampling (Bowden & Green, 2005) was used. Interdisciplinary courses at the university were identified via a review of course handbooks. Potential courses had to meet two criteria: (1) the description of the course had to either use the word 'interdisciplinary' or the related terms: 'multidisciplinary' or 'transdisciplinary'; and (2) the course had to have a teamwork project component that was open to students from two or more different disciplines to ensure continuity across the courses, to exclude courses that simply had content from different disciplines.

A maximum variation approach (Bowden & Green, 2005) was used. Potential participants were contacted from a sample pool of 80 courses. They were interviewed one by one until no new experiences were forthcoming. 59 participants were contacted in total; 36

responded to requests for interviews; 23 were interviewed. This was done to ensure diversity in participant representation from across the university's disciplinary areas and organisational structures.

Table 7.1

Profiles of study participants

Participant ID	Academic level	Years in academia	Disciplinary area	Years leading interdisciplinary courses
1	Professor	16+	Arts, Humanities and Social Sciences	3
2	Lecturer	6–10	Sciences	2
3	Lecturer	0–5	Business and Law	2
4	Lecturer	11–15	Medicine and Health	4
5	Lecturer	0–5	Engineering and Design	2
6	Lecturer	6–10	Business and Law	3
7	Lecturer	6–10	Engineering and Design	2
8	Professor	11–15	Sciences	2
9	Professor	11–15	Engineering and Design	6
10	Professor	11–15	Medicine and Health	3
11	Lecturer	11–15	Business and Law	3
12	Professor	16+	Arts, Humanities and Social Sciences	4
13	Professor	16+	Medicine and Health	5
14	Lecturer	11–15	Medicine and Health	3
15	Professor	11–15	Engineering and Design	5
16	Lecturer	6–10	Arts, Humanities and Social Sciences	1
17	Lecturer	16+	Arts, Humanities and Social Sciences	4
18	Professor	16+	Medicine and Health	5
19	Lecturer	0–5	Business and Law	2
20	Lecturer	16+	Sciences	4
21	Professor	16+	Sciences	4
22	Professor	16+	Arts, Humanities and Social Sciences	7
23	Professor	16+	Medicine and Health	7

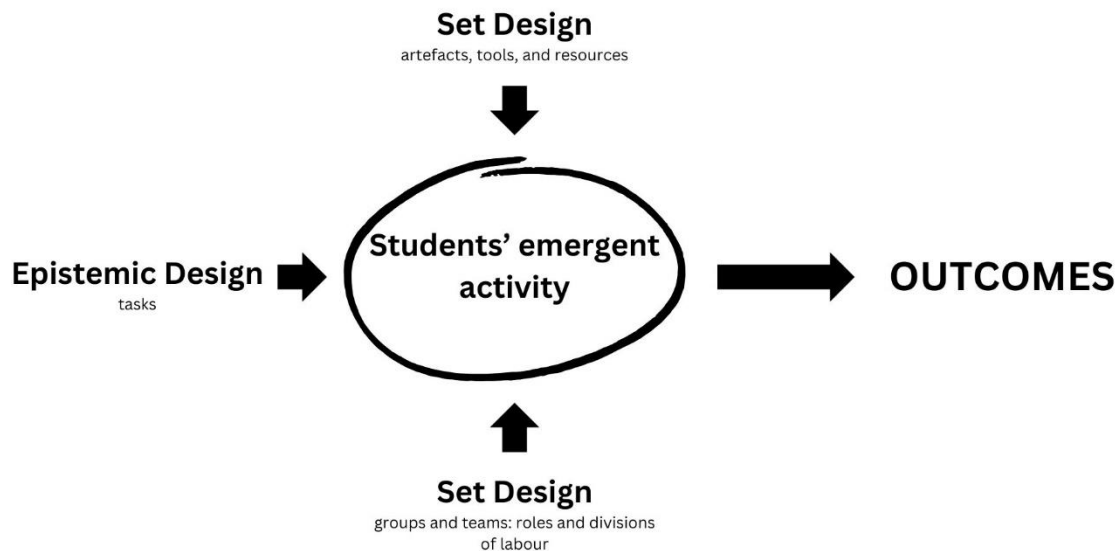
Videoconferencing software was used to conduct interviews, which were audio and video recorded. Interviews lasted between 50 and 90 minutes. They followed a semi-structured protocol that inquired about course leaders' backgrounds, design experiences, roles, understandings of interdisciplinarity, conceptions of the purpose of interdisciplinary education, and their experiences in designing for interdisciplinary teaching and learning. Course leaders were asked to provide examples of their design experiences and to describe walkthroughs of their approaches to designing courses. We used additional prompts to further investigate course leaders' responses or to probe responses for greater clarification. Additional prompting questions included: What have been your experiences in creating or co-creating interdisciplinary courses? How was the design process managed and organised? Can you walk me through the process? Who was involved in the design process?

Interview data was analysed, drawing upon phenomenographic techniques (Åkerlind, 2012; Marton, 1986) to construct an outcome space. An outcome space is composed of categories of description, which present what course leaders focused on, and dimensions of variation, which present the relationships between the different categories (Åkerlind, 2024).

In this article, we use "design" to connote the process of design, not its product (a course design). We investigate interdisciplinary design processes, which are both situated and complex. We use the Activity-Centred Analysis and Design (ACAD) framework, which is "a meta-theoretical framework for understanding and improving local, complex, learning situations" (Goodyear, Carvalho, and Yeoman 2021, p. 446) as a heuristic to direct interview questions to investigate the social, physical, and epistemic aspects of course leaders' experiences of design processes. The ACAD framework can be found in Figure 7.1.

Figure 7.1

ACAD framework (adapted from Carvalho & Goodyear, 2018, p.35)



The categories of description and the dimensions of variation were constructed using an iterative approach of sorting and finding similarities and differences in the semantic meaning of course leaders' statements. The first author conducted the initial analysis, and the categories were discussed and, as a result, refined collaboratively among the authors. This iterative process of analysis and refinement of the categories ensured the creation of a logically ordered and defensible outcome space.

A phenomenographic approach investigates the relationship between subjective experiences and objective phenomena. It is commonly used in educational research to explore phenomena that are experienced in different ways. Interdisciplinary education is multiple and situated (Vienni Baptista et al., 2020), and there are no standard pedagogical approaches to interdisciplinary teaching and learning (DeZure, 2017; Klein, 2005) and consequently, no standard design for interdisciplinary courses. Because of this, phenomenography is an

appropriate choice to explore how interdisciplinary course leaders experience design processes.

The study's outcome space is presented in Table 7.2. The table summarises the categories of description and the dimensions of variation. The outcomes are presented in greater detail, supported by quotes, in the following section. Participants' anonymity has been protected through the allocation of participant identification numbers (e.g., P6) tagged to participants' quotations. Additionally, ellipses were used to signify the removal of text deemed irrelevant to the research question. Italics were used to emphasise text that contains important details.

Outcomes

The constructed outcome space (Table 7.2) is comprised of four different ways that leaders experienced interdisciplinary course design processes, and six dimensions of variation. The categories advance from less to more complex design processes, starting with the ad hoc and on-the-run category, advancing to the greatest complexity in the design inquiry category. Additionally, the dimensions of variation are structured from less to more awareness given to them by course leaders. The outcome space therefore represents an expanding awareness of experiences of design for interdisciplinary teaching and learning.

The ACAD framework was used to guide investigation into course leaders' experiences (see Figure 7.1). The first two dimensions of variation that were generated from the interviews relate to responses regarding social aspects of design processes (design agency and social structures), the second two to set aspects of design processes (technologies and spaces), and the final two to epistemic aspects of design processes (design strategy and design knowledge).

The constructed outcome space (Table 7.2) is comprised of four different ways that leaders experienced interdisciplinary course design processes, and six dimensions of variation. The categories advance from less to more complex design processes, starting with the ad hoc and on-the-run category, advancing to the greatest complexity in the design inquiry category. Additionally, the dimensions of variation are structured from less to more awareness given to them by course leaders. The outcome space therefore represents an expanding awareness of experiences of design for interdisciplinary teaching and learning.

The ACAD framework was used to guide investigation into course leaders' experiences (see Figure 7.1). The first two dimensions of variation that were generated from the interviews relate to responses regarding social aspects of design processes (design agency and social structures), the second two to set aspects of design processes (technologies and spaces), and the final two to epistemic aspects of design processes (design strategy and design knowledge).

Category A: Ad hoc and on-the-run

In Category A, design experiences were described as solitary and unsupported. A high level of agency over how design was done, to a lesser extent, over what was designed was described, as courses were allocated, and design was viewed as an aspect of teaching duties. Significant design autonomy and responsibility in the design of new interdisciplinary courses were described:

I do find it quite curious that when a university engages someone to take on tasks like this, there aren't any kind of training guidelines at all. It's just, "We trust that you will do this to a good standard." (P5)

When I was being interviewed [for the job], I asked,... "So what is the approach? What's the model you're going to use?" ... And he said, 'That's for you to work out'. (P20)

Table 7.2 *Course leaders' experiences of interdisciplinary course design processes*

Categories Dimensions of variation	Category A Ad Hoc and On-the-Run	Category B Modification	Category C Dialogic Co-creation	Category D Design as Inquiry
1. Design Agency	Significant agency in course design, but limited support	No agency in initial course design, the agency in adapting designs for course enactment	Significant agency in course design, using informal partnerships to design	Significant agency in course design, using informal, ongoing networks of design support
2. Social Structures	Individuals working in isolation, seeking out design support	Formal communities of practice and buddy systems for teaching were formally established	Informal design partnerships developed in advance, linked to specific course design work	Established informal networks, employing a facilitated relational design approach with multiple stakeholders with distributed responsibilities; design experts involved with multiple stakeholders
4. Technologies	Asynchronously use of existing technologies for collective design	Repurposing of a learning management system to share resources	Collaborative technologies used for interactive codesign activities	Shared digital collaboration spaces and technologies integrated into, and used for multiple stages of design processes
3. Spaces	Using existing disciplinary spaces, isolated from potential collaborators	Shared spaces for teaching collaboration	Use of available spaces for collaborative design activity	Spaces, places, and tools are designed for multi-stage design and research processes
5. Design Strategy	Unplanned and rushed with no clear strategy	Outsourced course design	A creative approach to codesign, inclusive of colleagues and students	Research conducted to inform design; theoretically informed and empirically-driven
6. Design Knowledge	Drawing on design knowledge informally from educational designers not associated with the course	Drawing on design knowledge from prior leaders of the course	Design knowledge is distributed among members but not documented or made visible	Designers develop and capture design knowledge as a part of the design of the course, and of the design process

Design experiences were described as solitary, but it was common to seek out educational design support.

I've received feedback and critique from others, but I wouldn't say that I've co-designed (P5)

I'm relying a lot on other people to have networks or contacts... The big problem would be finding people who actually have an interest in curriculum development and designing (P4)

Preferences to design in person were expressed, as were as the use of known technologies rather than collaborative technologies.

My previous collaborations have been trying to write research papers, and usually I write the first draft and email the document to someone else. We're not used to having online real time collaborative tools. (P4)

The physical settings for working were described as situated within existing disciplinary spaces and infrastructures. Physical isolation from potential collaborators or educational designers was described as restricting both intentional and serendipitous networking.

So you've got the disciplinary silos, but then you start adding other factors like [physical] distance... it's not easy if someone's located across the faculty, or across the university somewhere...then it's got to be kind of a cold call. (P12)

Additionally, a lack of formal strategy and insufficient time for design was mentioned.

Usually [design] is done *very ad hoc and on-the-run*. (P12)

Learning was described in relation to the evaluation of the products of course design, not the design processes themselves:

We've got the ethics approval to run an evaluation on it from the students and the staff perspective. So we're currently doing that process now. (P23)

Despite there being significant design autonomy, limited formal design support was available to course leaders. This impacted their ability to exercise design agency effectively. They

described informally seeking out design support. Additionally, design knowledge was held within individuals and was neither captured nor shared.

Category B: Modification

In Category B, design experiences were described as adapting and enacting course designs that professional design teams had created. The absence of involvement in the creative process of designing was emphasised.

This is the first place I've come to where I don't have any autonomy, and everything's created for me. Literally, what I have to do is to just come in and teach the thing. (P11)

Social support structures were also configured for course leaders:

We became part of a community of practice. Also, once the project started, we were paired up with another team leader. So it was like a buddy system, really. (P12)

A learning management system was repurposed to store and share digital resources among course leaders:

A Canvas site... for teachers only. That is where we put all the materials for the teachers, including workshop outlines. It's a site that has been built throughout the years and becomes richer and richer. (P1)

Course design work took place in allocated physical spaces, intended to foster collegial support:

Many of us were working together in a very small physical space. We just had conversations about everything that came up... being in the same space and being available helped a lot. (P7)

However, design processes were neither structured nor strategic:

There were lots of meetings. They were always very unstructured, very meandering. (P7)

Design knowledge generated was not captured or shared but instead held by course leaders.

Prior leaders of the courses were viewed as a source of tacit design knowledge, with expertise specific to the course designs rather than course design processes:

These are wonderful people and very often I email them and say, look, I want to make this change. What do you think? They really know the course very well so they can give me great advice. (P1)

In the modification category, experiences were described as being separated from the design of courses. Statements therefore related to the adaptation of course designs their revision prior to subsequent course enactment. Course designs were viewed as reusable and refined over time. Limited design knowledge on course designs was retained in digital resources held in the repository, but most design knowledge on processes was neither captured nor inscribed. Design knowledge was solely held by prior course leaders and accessed through informal support.

Category C: Dialogic co-creation

In Category C, collaborations were described as formed in advance of course creation. Design processes were viewed as an opportunity to create innovative interdisciplinary courses.

Courses were often initiated at the school, faculty, or institutional level, but significant agency in both how courses were and what was designed was expressed:

We had to work within certain parameters but then the rest of it was just completely up to us... It's *a lot more dynamic space* than what we experienced with our other disciplines, and specific courses... ... *There's room to innovate.* (P23)

Course leaders described collaborations as self-organised and sustained. Collaborations were described as being generated at university-sponsored networking events or through individual networking and these collaborations needed to be fostered and sustained by course leaders:

At that time, I didn't have any relationships with other schools, but the faculty was doing this matchmaking exercise of having coordinators from different schools get together and we initiated some conversations. (P8)

I approached [senior professor] and requested him to give an inaugural lecture... Using that opportunity, I shared some of my interests with him and asked him to be part of a small grant proposal that was interdisciplinary (P17)

Digital spaces and design tools were described as augmenting synchronous collaborative design processes:

I put together a handful of things that seemed to work for an online collaboration. So, Miro because we do a design thinking workshop... Padlet has been useful to us as a wall like a notice board for the communities of practice to share those insights. And then we use Google Sheets I think for the group. (P20)

Different collaborative spaces in the university were used to host codesign activities. Shared physical spaces, rather than in digital spaces, were described as enabling a dialogic approach to design processes:

I think it's harder to do this work online. I do think there's something a little bit magical about being in the same space around a table with people... I'm good old school, but I feel like a human, the 'what if'... which are the sacred moments (P14)

Collegial dialogue was described as central to this approach. Discussions in design meetings supported innovative, emergent ideation and design. This strategy enabled group creativity and consideration of how designs would work in practice. Stakeholders in the design process could include students and other colleagues:

We got people into a room... and you just sit around, and that's how it works, and I think there's something about that. There's something about the pauses, and this group mind thing. The question hanging in the air... okay, what the hell are we here to do? ... and trying to precisely define that, but *in a placeholder way*. (P14)

Really good design is collaborative... My tendency is to design, either with my colleagues or with students. I do a lot of design work with students in terms of, how are we going to approach this? What's going to work here? (P12)

Learning was central to the design process. Course leaders described flexible design processes that require significant trust among collaborators:

We made a lot of things up as we went... we had of course a plan of topics beforehand, but... within that plan, we adjusted things as we went along and *had a lot of flex* (P15)

We all trust each other for the most part. There was a lot of shared trust. (P9)

Although design processes were not documented, evaluated, or inscribed, there was an expressed awareness of the potential benefits of capturing design processes to make them visible and thereby acknowledged by university leadership:

For us, it's just a blurry creative space, but to actually document the processes would be great... it actually captures stuff that otherwise isn't captured in any way. In the work we do as academics, *you're actually making it tangible*. I call it the *invisible work* of the academic. (P23)

Design processes were described as self-directed, collaborative design activities in service of educational innovation. However, the learning and knowledge generated in design processes was described as not being documented. This rendered both the design processes, and the design knowledge generated from the processes hidden and unshared.

Category D: Design as Inquiry

In Category D, conducting research to generate design knowledge to inform the product of the design process was described as central to design processes. Additionally, design knowledge was generated and captured to benefit both the design of the course, and to inform design practices. Design collaborations in this category focussed on experts in educational design but included other diverse stakeholders. Experiences describe deliberate design processes wherein course leaders were working as members of large design teams, researching while simultaneously designing.

A relational design approach was described wherein agency was distributed among stakeholders. The design processes were not only centred on creativity, but were strategically constructed through processes of inquiry:

I really enjoyed the approach that we had in terms of having different stakeholders involved, and having this dialogue from right from the beginning, trying to understand the needs of different users and... *let it unfold throughout the process* and the workshops. (P16)

However, the distributed design agency meant that decision-making was distributed, resulting in non-routine design processes:

Trying to have that flexibility in practice is not really easy in my experience. I would say that it is really challenging, especially for early career academics. It was one of those challenges that made it a bit stressful. (P16)

Greater detail was offered regarding how the social structures of the design team were sustained. Leaders were described as central to design processes to bring other stakeholders on board and to manage or facilitate the relational design processes:

You've got to have a vision, and you've got to persuade people to come on that journey with you... You've got to present the people who work with you with opportunities. (P21)

It's good if someone has that kind of... *I suppose the chairmanship role, but it seems to be more than that.* Being able to do that and also knowing when to when to go, that's enough... and saying, "now let's test that. Let's go and get evidence to support that" (P14)

Digital spaces and tools were also configured to support design processes. Design processes employed both synchronous and asynchronous components, but not in a sequential manner. The design environment was experienced as a composite of integrated physical, material, and digital components:

We used a shared drive or shared spaces, and we could work collaboratively on them... and of course, we did have the audio recording and the video recording of the writeable walls (P16)

Purposefully designed and resourced physical spaces were described as supporting design processes. In the following quote, a course leader describes how a space can enable and support different approaches to collaborative design:

[A design studio] allows for different forms of thinking, and different ways of collaborating. So people have the opportunity to think individually and to share too. Having that shared [whiteboard] wall really helps with collaborative thinking processes... that provides the freedom for people to walk around, share, to divide, to be in different teams, then to join together again, and have all these different sorts of combinations in their practice... for complex projects that area is helpful. (P16)

Additionally, the design strategy was informed by both educational theory and by conducting design research and drew upon people with backgrounds in educational design as well as other disciplinary fields:

At the core of this experience was that we had stakeholders involved right from the beginning, and we had people from different disciplinary backgrounds... and different roles—a student, as a postgrad, and as senior academics, and people with technology backgrounds, those who had expertise in educational design... they knew the theories behind educational design and had formal practice and engagement around educational design too. (P16)

This design strategy positioned design as flexible. In this category, flexible design processes continued beyond pre-course enactment design into design during the enactment of the course, enabling ongoing adaptation to the emergent needs of teachers and students in teaching and learning activity:

A thing that was really interesting about the design of that course is that we allowed for things to emerge even as the courses started. So, I think we had a space to add few things or change or modify (P16)

The design strategy employed a relational design approach but was facilitated by an educational expert who gave ongoing guidance and feedback to members of the codesign team throughout the design process.

I remember working on the course outline document, finding resources, every week and working on the methodology document we were working on it together, alongside [academic mentor], and she was continuously providing us feedback on all these different aspects (P16)

Learning was viewed as a central component of design work. Learning to design was viewed as integral to the advancement of university interdisciplinary education.

It's about staff and students co-creating and co-designing things... and leveraging off the expertise that they would not have come across before. So it depends if you're here at university to teach, or here to learn and teach. (P19)

Strategic generation and documentation of design knowledge was viewed as central to design processes to inform the next steps in design processes:

The way that we approached this was that we ran a series of workshops... we had the outcome of each workshop analysed prior to participation in the next workshop so that we could share the key points, and then talk about the next step, and what needed to be done. (P16)

In summary, design for interdisciplinary teaching and learning was experienced as a process of conducting research as a part of design work. It was characterised by ongoing inquiry and

led by educational experts using a relational design approach. Stakeholders were not simply diverse; design teams strategically included people with different disciplinary backgrounds, expertise, and positions within the university, including students. The codesign process aimed to generate design knowledge and develop the institution's capability to design for interdisciplinary education.

Relationships Between the Categories

The categories of description represent the four different ways interdisciplinary course designers experience design processes. The structural relationships between the different categories of experience are most evident when explored through the six dimensions of variation. Dimensions 1 and 2 relate to social aspects, Dimensions 3 and 4 relate to set aspects, and Dimensions 5 and 6 relate to epistemic aspects of design processes. Advancing from Category A to D, course leaders' experiences aligned with an expanding inclusion of dimensions that they focused upon.

In Dimension 1—design agency—course leaders had different levels of autonomy and agency in course creation concerning their institution. In Category A, there was full autonomy to create courses but little support, resulting in limited agency. In Category B, there was no participation in course creation, resulting in no autonomy and limited agency. In contrast, in Category C, design was viewed as an opportunity to innovate, while in Category D, design processes centred on conducting inquiry. Whereas course leaders described their experiences as isolating in Categories A and B, they described them as explorative and generative in Categories C and D when they had autonomy and agency in course design.

In Dimension 2, the social structures involved in the design processes became increasingly sophisticated and increasingly reliant upon collegial networks of support. In Category A, support was sought out. In Category B, course leaders played no role in course creation but were enrolled in partnerships and communities to support course modification. In

Category C, support was formed and sustained through partnerships and collaborations. In Category D, support was *led and sustained through the development of networks* including experts in educational design and design research. Across the categories, course leaders sought out, formed, joined, and sustained informal networks for educational design support. In all cases, course leaders described seeking out informal communities and networks in their design processes.

In Dimension 3, advancing across the categories, design experiences reflected an increasing use of a greater number of technologies, using technologies to serve different purposes, and great intentional use of technologies. In Category A, existing academic technologies were used for collective design work. In Category B, a course hosting platform was repurposed to act as a repository for shared digital resources for teaching. In Category C, multiple technologies were used, mainly to augment synchronous design activity and to develop course designs asynchronously. In Category D, multiple technologies and material tools were used for project infrastructure, ideation, and capturing data throughout the design process, not just during specified in-person design activities. Technology was used to share resources and contribute to designs in Categories A and B, to support design processes in Category C, and to both facilitate and document design processes in Category D. Moving across the categories, there was a distinct increase in the configuration of multiple technologies to support and enhance design processes, not just for work on the course designs.

In Dimension 4, the spaces used for design activity were described as increasingly purposeful, advancing across the categories. Once again, in Category B course leaders were left out of this process and described as co-inhabited workspaces instead. Advancing across Categories A, C, and D, course leaders described increasing awareness and intentional use of their physical settings in design processes. In Category A, existing disciplinary spaces housed

individual course leaders, physically separated from potential collaborators. In Category C, arranged meeting spaces were used for design activities. In Category D, spaces used were purposefully designed to host collaborative design work. Advancing across Categories A, C, and D, course leaders described design experiences as more intentional, involving more people, and planning out the physical and material infrastructure to support design work, enabling greater flexibility in design processes.

In Dimension 5, course leaders experienced participating in increasingly sophisticated and complex design strategies, advancing across the categories. In Category A, no strategy to guide design processes was emphasised. Again, in Category B, course leaders described collaborative teaching meetings. In Category C, course leaders described flexible, dialogic approaches to design processes that emphasised collaborative idea generation and innovation. Lastly, in Category D, course leaders described an elaborate, multi-faceted approach to design processes informed by educational research. A relational design approach was described that involved stakeholders from different disciplinary backgrounds conducting and analysing research both before and during the enactment of the courses. Whereas Categories A and B were unstructured, Category C was characterised by the use of collaborative design thinking approaches, and Category D employed an intentional relational design approach, employing design thinking and strategic inquiry as central components of the design process to inform the course design.

Lastly, in Dimension 6, an awareness of the design knowledge generated in design processes increased, advancing across Categories A to D. In Category A, course leaders drew upon the design knowledge of others but did not describe developing it themselves. In Category B, course leaders were separated from course design processes and thereby separated from the design knowledge generated in course creation. They described design knowledge as relating to course designs held by prior course leaders. In Category C, design

knowledge was distributed among designers in teams, but any design knowledge generated in design activity was not documented, rendering it invisible. Lastly, in Category D, design knowledge was intentionally collected, informing not only the development of the course design but the design processes as well. In Categories A, B, and C, design knowledge was held within design artefacts or held within designers themselves. Only in Category D was design knowledge collected, documented, and made explicit. Notably, despite the intention, in Category C there was insufficient time and resources to research and document design processes and generate design knowledge.

Advancing across the four categories, course leaders' experiences showed an incremental awareness of, and intentionality given to strategic design processes, thereby enabling course leaders to be prepared to address complexity in the design of interdisciplinary courses. Course leaders focused on increasingly more aspects of design processes moving from Category A to D.

Discussion

Our outcomes make three contributions to the study of design for interdisciplinary teaching and learning.

First, the development of interdisciplinary education in universities is often described as being driven by individuals (Lyall et al., 2016; Lindvig et al., 2019). Our outcomes, however, show that in all categories, course leaders sought out and developed communities and networks that took part in their design processes. Our outcomes show that interdisciplinary course design processes are almost exclusively experienced collaboratively. Even course leaders in Category B who were given significant institutional support sought out external collegial educational design support. While our outcomes show that enterprising individuals (Lyall et al., 2016) are common, they do not work as 'lone wolves' as they have been perceived by some university leaders. Instead, they seek out, establish, and sustain

communities and networks to support their design work. Educational design for interdisciplinary teaching and learning is commonly characterised by complexity and challenges in the literature (Ashby & Exter, 2019; Bopardikar et al., 2021). Further, McKenney (2015) and Ellis and Goodyear (2019) have argued that with increased design scope and complexity, larger design teams and more collaboration are a necessity. Our outcomes show that design for interdisciplinary teaching and learning is experienced collaboratively and should be understood as collaborative design work.

Second, our outcomes show the importance of an awareness of the design environment for design processes. Goodyear (2021) states that educational design activity is always situated, and what designers can do in design activity "is influenced in subtle and powerful ways by the social, physical, and epistemic constraints and affordances of the situation" (p. 244). Our outcomes provide examples of the affordances and constraints of design environments on design processes at one university. For example, in Category A, course leaders are physically isolated from potential collaborators, whereas in Category D, a course leader described the use of a purposefully designed lab for collaborative design work that enabled different ways of working and thinking, expanding what was possible in design processes. Further, in Categories A and B, course leaders used spaces and technologies available to them in their design processes, but in Categories C and D, course leaders used physical spaces strategically and configured multiple technologies and digital spaces to support collaborative design processes. They intentionally designed aspects of their environments to support their design processes, and as a result, their educational design processes were much more intentional and complex. Our outcomes show that environments can impact interdisciplinary educational design processes, but environments can be configured to support design processes to deal with the complexity of designing interdisciplinary courses.

Third, although course leaders described significant learning taking place during design processes, it was rarely explicitly researched and documented. Prior theoretical literature has argued that design knowledge is often unarticulated and left unshared (McKenney, 2015). In Category D, however, course leaders conducted inquiry to generate design knowledge to inform course design. Course leaders did note the desire to conduct research to capture design knowledge, but capturing, let alone sharing, and building on design knowledge was rare, largely due to time and resource constraints.

Conclusions

This article reports on the variation in how course leaders experience design processes when developing interdisciplinary courses. It provides empirical evidence that can inform processes of design for interdisciplinary course development. This work contributes meaningful empirical insights to discourse in the literature that frames interdisciplinary educational practices as situated. It shows variation in the situated nature of design processes. This can help course leaders strategically address the complexity of not only the design of interdisciplinary courses but also inform their configuration of appropriate design processes for themselves. Central to this contribution to knowledge is that with or without institutional support, course leaders actively design their environments for educational design work.

We further conclude that although educational design for interdisciplinary teaching and learning may be experienced as isolated, challenging, and at times under-supported, it is not experienced as a solitary endeavour. It is characterised by collaborative work making use of a mix of institutionally provided and collegially formed support networks. Our outcomes show that design for interdisciplinary teaching and learning is experienced as complex and challenging, and therefore we argue that interdisciplinary educational design practices be framed as such — complex, challenging, and collaborative — so that resourcing, professional

development, and research can align with this characterisation rather than treating it as an aspect of an individual's teaching duty, which is a component of leading a course.

We acknowledge that it is a common theme in the literature on educational design that design knowledge is not commonly captured, documented, or built upon in practice. Our outcomes show that although there is an awareness of the value of researching design practices to generate design knowledge due to the resource-intensive, challenging nature of design processes, it rarely happens. We suggest that existing research-centred design knowledge, such as design principles, be made readily available to course leaders, and we suggest that resourcing be set aside to research course leaders' interdisciplinary course design processes to develop local, experience-centred design knowledge that can be of practical use to the people responsible for developing and sustaining interdisciplinary courses.

Acknowledgments

This research was partly funded by the Australian Research Council through Discovery Project grant DP200100376 (Developing interdisciplinary expertise in universities).

Declarations

The authors report there are no competing interests to declare.

References

- Åkerlind, G. S. (2012). Variation and commonality in phenomenographic research methods. *Higher Education Research and Development*, 31(1), 115–127.
<https://doi.org/10.1080/07294360.2011.642845>
- Åkerlind, G. S. (2024). Common misunderstandings of phenomenographic research in higher education. *Higher Education Research and Development*, 1–16.
<https://doi.org/10.1080/07294360.2023.2218804>

- Ashby, I., & Exter, M. (2019). Designing for interdisciplinarity in higher education: Considerations for instructional designers. *TechTrends*, 63(2), 202–208. <https://doi.org/10.1007/s11528-018-0352-z>
- Bennett, S., Agostinho, S., & Lockyer, L. (2017). The process of designing for learning: understanding university teachers' design work. *Educational Technology Research and Development*, 65(1), 125–145. <https://doi.org/10.1007/s11423-016-9469-y>
- Bennett, S., Lockyer, L., & Agostinho, S. (2018). Towards sustainable technology-enhanced innovation in higher education: Advancing learning design by understanding and supporting teacher design practice. *British Journal of Educational Technology*, 49(6), 1014–1026. <https://doi.org/10.1111/bjet.12683>
- Bopardikar, A., Bernstein, D., Drayton, B., & McKenney, S. (2021). Designing educative curriculum materials in interdisciplinary teams: Designer processes and contributions. *Instructional Science*, 49(2), 249–286. <https://doi.org/10.1007/s11251-021-09538-5>
- Bowden, J. A., & Green, P. (Eds.). (2005). *Doing developmental phenomenography*. RMIT University Press.
- Bowers, S., Chen, Y.-L., Clifton, Y., Gamez, M., Giffin, H. H., Johnson, M. S., Lohman, L., & Pastryk, L. (2022). Reflective design in action: A collaborative autoethnography of faculty learning design. *TechTrends*, 66(1), 17–28. <https://doi.org/10.1007/s11528-021-00679-5>
- Carvalho, L., & Goodyear, P. (2018). Design, learning networks and service innovation. *Design Studies*, 55, 27–53. <https://doi.org/10.1016/j.destud.2017.09.003>
- Christensen, I.-M. F., & Markauskaite, L. (2025). Creating reusable design knowledge in interdisciplinary education: Current methodological practices and issues. In I.-M. F. Christensen, L. Markauskaite, N. B. Dohn, D. Ripley, & R. Hachmann (Eds.), *Creating design knowledge in educational innovation: Theory, methods, and practice* (pp. 96-109). Routledge. <https://doi.org/10.4324/9781003391432-12>
- Cremers, P. H. M., Wals, A. E. J., Wesselink, R., & Mulder, M. (2017). Utilization of design principles for hybrid learning configurations by interprofessional design teams. *Instructional Science*, 45(2), 289–309. <https://doi.org/10.1007/s11251-016-9398-5>
- DeZure, D. (2017). Interdisciplinary pedagogies in higher education. In R. Frodeman, (Ed.), *The Oxford handbook of interdisciplinarity* (2nd ed., pp.558–572). Oxford University Press. <https://doi.org/10.1093/oxfordhb/9780198733522.013.45>

- Ellis, R. A., & Goodyear, P. (2019). *The education ecology of universities: Integrating learning, strategy and the academy*. Routledge.
<https://doi.org/10.4324/9781351135863>
- Goodyear, P. (2015). Teaching as design. *HERDSA Review of Higher Education*, 2, 27–50.
- Goodyear, P. (2018). Design research. *Health Education in Practice: Journal of Research for Professional Learning*, 1(1).
- Goodyear, P. (2021). Afterwords: Considering the postgraduate, postdigital and postcritical. In T. Fawns, G. Aitken, D. Jones (eds) *Online Postgraduate Education in a Postdigital World*. Springer. https://doi.org/10.1007/978-3-030-77673-2_13
- 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>
- Goodyear, P., & Ellis, R. A. (2020). Ecological thinking about education strategy in universities. In R. Barnett & N. Jackson (Eds.), *Ecologies for learning and practice: Emerging ideas, sightings and possibilities*. Routledge.
<https://doi.org/10.4324/9781351020268-7>
- Goodyear, P., Markauskaite, L., Wrigley, C., Spence, N., Mosely, G., & Swist, T. (2023). Constructing design knowledge for postdigital science and education. In Postdigital Science and Education P. Jandrić, A. MacKenzie, & J. Knox (Eds.) *Constructing Postdigital Research*. Springer. https://doi.org/10.1007/978-3-031-35411-3_4
- Kidron, A., & Kali, Y. (2015). Boundary breaking for interdisciplinary learning. *Research in Learning Technology*, 23. <https://doi.org/10.3402/rlt.v23.26496>
- Klein, J.T. (2005) Integrative learning and interdisciplinary studies. *Peer Review*. 7(4) 8–10.
- Laurillard, D. (2012). *Teaching as a design science: building pedagogical patterns for learning and technology*. Routledge.
- Lindvig, K., Lyall, C., & Meagher, L. (2019). Creating interdisciplinary education within monodisciplinary structures: The art of managing interstitiality. *Studies in Higher Education*, 44(2), 347–360. <https://doi.org/10.1080/03075079.2017.1365358>
- Lindvig, K., & Ulriksen, L. (2019). Different, difficult, and local: A review of interdisciplinary teaching activities. *Review of Higher Education*, 43(2), 697–725.
<https://doi.org/10.1353/rhe.2019.0115>

- Lyall, C., Meagher, L., Bandola, J., & Kettle, A. (2016). Interdisciplinary provision in higher education: Current and future challenges. *Higher Education Academy*.
<https://documents.advance-he.ac.uk/download/file/document/4604>
- Marton, F. (1986). Phenomenography — A research approach to investigating different understandings of reality. *Journal of Thought*, 21(3), 28–49.
- 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>
- Øland, T., Sauzet, S., Ryberg, M. L., & Lindvig, K. (2022). *Configurations of interdisciplinarity within education: Danish experiences in a global educational space*. Routledge. <https://doi.org/10.4324/9781003083245>
- Ripley, D., Markauskaite, L., & Goodyear, P. (2023). A phenomenographic exploration of course leaders' understandings of interdisciplinarity. *Studies in Higher Education*.
<https://doi.org/10.1080/03075079.2023.2293932>
- Vienni Baptista, B., Fletcher, I., Maryl, M., Weislik, P., Buchner, A., Lyall, C., Spaapen, J., & Pohl, C. (2020). *Final report on understandings of interdisciplinary and transdisciplinary research and factors of success and failure*. Zenodo.
<https://doi.org/10.5281/zenodo.3824839>

Chapter 8: Developing and sustaining interdisciplinary courses: Course leaders' experiences of their institutional environment

Dwayne Ripley, Lina Markauskaite & Peter Goodyear.

Submitted to *Higher Education Research and Development*.

Designing for interdisciplinary teaching and learning is a situated practice. Haggis (2003) has argued that phenomenographic research can be narrow if it is not considerate of the complexities of location and context. This study addresses this concern by investigating experiences of developing and sustaining interdisciplinary courses in relation to the institutional environment in which they take place. The prior articles (Chapters 4, 5, 6, and 7) are nested within this level of investigation (see Figure 2.1).

This chapter is written as a journal article that has been submitted to *Higher Education Research and Development*. It may be revised for publication following feedback from reviewers.

For this article, I conducted data collection, data analysis, and the original draft preparation and revisions based on feedback from both supervisors and from two anonymous peer reviewers. Lina Markauskaite was responsible for reviewing and editing multiple drafts of the paper, and conducting data analysis, and Peter Goodyear was responsible for reviewing and editing drafts. My contribution to the paper is estimated at 75% and my supervisors at 25%.

Developing and sustaining interdisciplinary courses: Course leaders' experiences of their institutional environment

Abstract

Universities around the world are increasing the number of interdisciplinary courses they offer. To do this effectively, there is a need to better understand how interdisciplinary courses are developed and sustained within institutional environments established to support disciplinary programmes and courses. This study uses a phenomenographic approach to answer the question: How do course leaders experience their institutional environments when developing and sustaining interdisciplinary courses? Outcomes from interviews with 23 participants show that course leaders collectively experience their institutional environments in four qualitatively different ways, as: A) fixed, B) resistant to change, C) adapting, and D) restructured. The former two ways of experiencing the institutional environment are characterised by working within constraints, necessitating excessive individual effort to develop and sustain interdisciplinary courses. The latter two ways of experiencing it view the institutional environment as open to change. The study's outcomes show that interdisciplinary course leaders' practices are not only shaped by their institutional environment, but that course leaders, in turn, can have some agency to shape their institutional environment. These outcomes can be used by interdisciplinary course leaders and university administrators in making decisions aimed to support sustainable practices in interdisciplinary education.

Keywords: Interdisciplinary education, Institutional environments, Phenomenography, Course design practices; Institutional sustainability

Introduction

Interdisciplinary education plays an increasingly prominent role in higher education (Cai & Lönnqvist, 2022; Lyall et al., 2016). However, interdisciplinary education presents significant challenges as interdisciplinary programmes and courses often need to be developed and enacted within university institutional environments that have been historically organised and built to support disciplinary teaching and learning practices (Lindvig et al., 2019). This issue

is further exacerbated at larger research-oriented universities where disciplines are often used as a basis for institutional structures—departments, schools, faculties, etc. (Holley & Szostak, 2022). Addressing these incongruities can be difficult. Interdisciplinary course leaders need to learn how to design and enact interdisciplinary courses but also need to learn how to navigate institutional environments that were not necessarily built to support interdisciplinary educational practices.

The different manifestations that interdisciplinary teaching and learning practices take are entangled with and shaped by other situated practices (Sauzet et al., 2023). Research studies that do not take into account the situated nature of interdisciplinary education tend to universalise findings (Lindvig & Ulriksen, 2019), limiting their usefulness for those seeking to apply them in their own contexts. The situated nature of interdisciplinary educational practices therefore makes it integral to study practices in relation to their institutional environment to make the outcomes useful to practitioners.

This study contributes to a growing body of research that investigates how interdisciplinary education is developed and sustained in universities that structure research and education around disciplines (Lindvig et al., 2019; Lyall et al., 2016; Øland et al., 2023). It also contributes an Australian perspective to the literature that acknowledges the situated nature of interdisciplinary educational practices that have so far been predominantly focused upon European and American universities. A significant body of literature identifies a lack of alignment between high-level institutional management and leadership perspectives (Franks et al., 2007; Holley, 2009; Lindvig, 2023). This study contributes middle-level practitioners—i.e., course leaders—perspectives on their experiences of their institutional environment. These perspectives provide a view *from within* that complements university leadership's view *from above* when shaping a university's activity systems (Ellis & Goodyear, 2019).

This study answers the research question, *How do course leaders experience their institutional environments when developing and sustaining interdisciplinary courses?*

Interdisciplinary education and institutional environments

Understanding interdisciplinarity education requires investigation of its practices as well as the forms of organisation in which its practices manifest (Ryberg et al., 2023). The importance of the organisational settings is apparent in the literature. For example, in a study investigating configurations of interdisciplinary activities across the Danish educational system, Øland et al. (2023) show that educational environments influence the forms that interdisciplinary education takes, emphasising that the flexible and emergent nature of interdisciplinary teaching and learning is often in tension with disciplinary course structures, which are commonly standardised. Further, in Finland, Cai and Lönnqvist (2022) identify challenges faced when implementing interdisciplinary degree programmes, including compatibility issues, increased costs and leadership responsibilities, and faculty-level concerns, proposing management solutions to resolve the issues. Lastly, in the United States, Holley (2009) identify conflict between interdisciplinary curricula and the disciplinary structures that support them. Together, these studies conducted across diverse contexts identify many challenges faced when developing interdisciplinary courses within disciplinary structures but give limited attention to how people address the challenges in relation to their institutional environments. Exploring how course leaders address the challenges they face is important because educational practices are not only influenced by their institutional environments; educators also have the potential to influence their institutional environments (Brew et al., 2022).

While some scholars increasingly question whether academic disciplines are monolithic and central to the organization of teaching and learning in contemporary universities (Aldrich, 2014; Trowler, 2020), many universities remain shaped by discipline-

based structures that can limit the resourcing available to interdisciplinary endeavours (Holley & Szostak, 2022).

To advance interdisciplinary education, Lyall et al. (2016) suggest that universities support passionate individuals who work against established institutional structures by sharing their good practices. Ashwin (2020), however, has described such approaches as a contagion theory of change, which is assumed to lead to lasting change but argues that change rarely eventuates. This can be particularly problematic because interdisciplinary educational activities are both time-consuming (Lindvig, 2023) and resource-intensive (Lyall et al., 2016). Adequate funding and institutionalisation are critical for sustaining interdisciplinary education in universities (Vienni Baptista et al., 2022). Institutionalisation of interdisciplinary courses could help to ensure that experiences, theories, methods, and practices are retained, so they do not need to be rediscovered in each subsequent activity (Pohl, 2022). This, as Lindvig (2023) argues, is also necessary to ensure that “faculty and students wishing to pursue an interdisciplinary trajectory are not left on their own, frustrated, overworked, or dead-ended” (p. 114). However, perspectives on institutionalisation vary. Vienni Baptista et al. (2022) have argued that institutionalisation should be ‘transformational’ and must take a multifaceted approach across an institution—arguing that piecemeal approaches have little potential to support and sustain interdisciplinary education and may unintentionally reinforce the status quo. Holley and Szostak (2022) alternatively argue that the development of interdisciplinary education in universities more commonly takes place slowly and gradually over decades. Regardless of how change happens and how long it takes for change to happen, the emphasis on the challenges course leaders face in relation to their institutional environments (Cai and Lönnqvist, 2022; Holley & Szotstak, 2022; Lindvig et al., 2019) highlights the need for universities to adapt their institutional environments to better support the development and sustainability of interdisciplinary courses.

When interdisciplinary courses are developed and sustained within discipline-based institutional structures, course leaders can face substantial challenges. However, institutional structures can problematically be conflated with disciplinarity in general. Klein (2010) argues that although organisational structures grounded in the disciplines may be resistant to change, the disciplines themselves are not. Brew (2007) similarly argues that the disciplines are in constant evolution. Lindvig and Ulriksen (2019) found that interdisciplinarity education is often framed as ‘other than’ disciplinary education. In contrast with this common framing, Holley and Szostak (2022) argue that the relationship between interdisciplinary and disciplinary education is one of mutual advancement.

This study, therefore, by focussing on the interdisciplinary course leaders’ experiences, explores the challenges they face in relation to their institutional environment when developing and sustaining interdisciplinary courses and how they address the challenges they face, thus generating valuable insights into course leaders’ experiences of shaping their institutional environment.

Phenomenography

This study employs a phenomenographic approach (Marton, 1986; Marton & Booth, 2013). Phenomenography is often used to research the qualitatively different ways that a group of people understand, conceive of, or experience a phenomenon (Han & Ellis, 2019). Its purpose is both to *explore* and to *logically map out* the relationships, including differences and similarities, between variations in how a phenomenon is experienced (Åkerlind, 2024). It aims to expand awareness of the variation in how this phenomenon is experienced. Building on this rationale, this study does not aim to identify a correct way of developing and sustaining interdisciplinary courses in relation to an institutional environment, rather, it aims

to explore variations in course leaders’—who are tasked to develop and sustain interdisciplinary courses—experiences of this environment.

Sample and Data Collection

The study was based on interviews with 23 academics who led or significantly contributed to the design, redesign, configuration, or implementation of interdisciplinary courses. The study sample was composed of 12 female and 11 male participants, of whom 12 held lecturer-level posts (Lecturer or Senior Lecturer) and 11 held professorial-level posts (Associate Professor or Professor). Participants had diverse academic backgrounds, including six from medicine and health, four from the sciences, four from engineering and design, five from the arts and humanities, and four from business and law. Participants had between one and 30 years of experience as academic educators and between 1 and 7 years of experience leading interdisciplinary courses (Table 1).

Table 8.1 Profiles of study participants

Participant ID	Academic level	Years in academia	Disciplinary area	Years leading interdisciplinary courses
1	Professor	16+	Arts, Humanities and Social Sciences	3
2	Lecturer	6–10	Sciences	2
3	Lecturer	0–5	Business and Law	2
4	Lecturer	11–15	Medicine and Health	4
5	Lecturer	0–5	Engineering and Design	2
6	Lecturer	6–10	Business and Law	3
7	Lecturer	6–10	Engineering and Design	2
8	Professor	11–15	Sciences	2
9	Professor	11–15	Engineering and Design	6
10	Professor	11–15	Medicine and Health	3
11	Lecturer	11–15	Business and Law	3

12	Professor	16+	Arts, Humanities and Social Sciences	4
13	Professor	16+	Medicine and Health	5
14	Lecturer	11–15	Medicine and Health	3
15	Professor	11–15	Engineering and Design	5
16	Lecturer	6–10	Arts, Humanities and Social Sciences	1
17	Lecturer	16+	Arts, Humanities and Social Sciences	4
18	Professor	16+	Medicine and Health	5
19	Lecturer	0–5	Business and Law	2
20	Lecturer	16+	Sciences	4
21	Professor	16+	Sciences	4
22	Professor	16+	Arts, Humanities and Social Sciences	7
23	Professor	16+	Medicine and Health	7

For this study, purposeful sampling (Bowden & Green, 2005) was used. To identify interdisciplinary course leaders, we first searched the university's course handbook to identify all interdisciplinary courses to identify potential participants. The criteria for the courses to be considered *interdisciplinary* included: (1) course descriptions were required to use the term 'interdisciplinary' or the similar and often interchangeably used terms - 'multidisciplinary' and 'transdisciplinary'; and (2) the courses were required to have a teamwork component that had students from different disciplinary backgrounds working together. This was done to ensure a level of consistency across the types of courses participants experienced.

The next step in identifying potential participants involved a maximum variation approach (Bowden & Green, 2005). This involved reviewing the disciplinary backgrounds of course leaders identified in the course outlines to ensure participant representation from across the breadth of the university's faculties and organisational structures. Prospective

participants were then contacted sequentially over the span of months and interviewed at times convenient to them. From the sampling pool comprised of 80 courses, 59 potential participants were contacted, of which 36 responded and 23 agreed to be interviewed.

The interviews were conducted using video conferencing software and were audio recorded. Interviews lasted from 50 to 90 minutes. Interviews followed a semi-structured protocol of asking course leaders about their disciplinary, educational, and educational design backgrounds, their understandings of interdisciplinarity and its purpose in higher education, and their experiences with creating interdisciplinary courses.

To study course leaders' experiences of their institutional environment when developing and sustaining interdisciplinary courses, we used the Activity-Centred Analysis and Design (ACAD) wireframe (Goodyear et al., 2021) as a visual scaffold to guide questions in the interview. Its use ensured that investigation of course leaders' experiences were conducted across scale-levels—with a focus on the macro scale-level in this case, investigating the role of digital and physical infrastructure, forms of knowledge production and sharing, and forms of organisational structures.

Figure 8.1 *The ACAD wireframe (Adapted from Goodyear et al., 2021)*

	Set Design	Epistemic Design	Social Design
Macro level	<i>Buildings & technology</i>	<i>Stakeholder values</i>	<i>Organisational structures</i>
	Physical and digital infrastructure	Forms of knowledge production & sharing	Structures in use: hierarchal, networked...
Meso level	<i>Allocation/use of Spaces & technology</i>	<i>Curriculum</i>	<i>Community</i>
	Availability, access, and choice	Activities, courses, programmes, degrees	Interdisciplinary, Disciplines, industry...
Micro level	<i>Artifacts, tools & resources</i>	<i>Selection, sequence & pace</i>	<i>Divisions of labour & roles</i>
	Tools, tech devices, whiteboards...	Content, sequencing, task types	Facilitation, group structures, scripts...

During the interviews, the following main questions were asked:

- 1. Please describe any challenges you faced when designing interdisciplinary courses and how you overcame them and learned from them.*
- 2. Please describe any enablers that helped you to design and describe how they helped you and what you learned from those experiences.*

These questions were followed by a range of probing questions, based on the ACAD, asking participants to elaborate upon or clarify details. This protocol was approved by the University of Sydney's Human Research Ethics Committee (Approval #2020/668).

Data Analysis

The analysis of the interviews employed phenomenographic techniques (Åkerlind, 2012; Marton, 1986). This involved an iterative process of looking at the data from different perspectives at different times to manage the large amount of data collected. First, the first author listened to all interviews to develop familiarity with the data, then transcribed the interviews verbatim. The transcripts were uploaded to NVivo, the software that was used to manage the iterative data analysis process. The first author grouped quotes by semantic similarity and then reviewed the groupings against each other as patterns were identified. Through this process of sorting and moving quotes, categories of description and dimensions of variation were constructed. Together with the second author, the categories of description and the dimensions of variation were further adapted and refined. A coherent and defensible outcome space was formed from this ongoing review and refinement. The constructed outcome space presents not only the different ways a phenomenon is experienced, advancing hierarchically from less elaborate to more elaborate ways of experiencing the institutional environment, but also the relationships between them (Åkerlind, 2024).

The anonymity of the participants was protected by allocating identification numbers (e.g., P7) that were tagged with the participants' statements. Ellipses were also used to signify the omission of text that was deemed less relevant to answering the research questions. Lastly, italics were used to signify important details presented in participants' statements.

Outcomes

The outcome space included four categories of description and four dimensions of variation (Table 2). The cells of the table that are not shaded are associated with course leaders' experiences of having limited agency to enact change upon their institutional environment, whereas the cells of the table that are shaded are associated with course leaders' experiences of having some awareness of and agency to enact change upon their institutional environment, informally or directly.

Category A: Fixed

In Category A, experiences of institutional environments were described as working within existing, fixed disciplinary structures when developing and sustaining interdisciplinary courses, which were viewed as more difficult to develop and sustain than disciplinary courses.

*It's very hard to do this. I think *interdisciplinarity courses have to be looked at in a different light than other courses.* (P2)*

Course leaders described an absence of an interdisciplinary social infrastructure and a subsequent reliance upon informal collegial networks. They also expressed a concern over the viability of the informal networks.

*I'm a scientist, and I'm interested in the science... That's my big problem, I guess. *I'm relying a lot on other people to have networks or contacts because I don't have a network of collaborators.* (P6)*

*At some stage, academics [who help others with design] will start pushing back and going saying, "no, sorry"... I think *there's a real risk to the informal network.* (P16)*

Table 8.2 Course leaders' experiences of their institutional environments when developing and sustaining interdisciplinary courses

Category Dimension	A – Fixed	B – Resistant to Change	C – Adaptable	D – Restructured
Social Infrastructure	Collegial support sought; collegial networks used	Partnerships and collegial networks formed, sustained, and used	Self-organised networks of experts formed, sustained, and used	Professional development teams; organised collegial support for course enactment
Resourcing	Common workload allocation (no additional funding)	One-off funding to support course creation	One-off funding to support course creation; further funding is requested when the need is identified	Well-funded course creation and refinement
Development of Expertise	Self-directed learning within the university	Self-directed learning extends beyond the university	Mentorship and collegial learning with experts at the university	Institutionally-provided courses and workshops
Organisational Structures	Organisational structures are maintained	Organisational structures are overcome or worked around in different ways, but not changed	Organisational structures are changed in moderate ways, based on identified situational needs	Organisational structures are restructured to accommodate the implementation of specific courses

Despite being perceived to be more difficult and resource-intensive than disciplinary courses, the resourcing and workload allocation were the same as disciplinary courses. Course leaders described this as potentially limiting the quality and scope of what they could accomplish.

There is *no budget* behind it. It's just what the university provides as part of our roles. (P3)

A lot of this is *very rushed*... it has a bearing on how thorough you are, and what you can and can't do in that time. (P5)

Course leaders described developing expertise for interdisciplinary course leadership on their own, including determining what to learn and self-directing their own learning.

I took on this job and I'm confident that I'm able to do it. But if I looked at my experience and the training that I received and the confidence that people had in me in terms of the teaching of these things, I'd have to say *I was woefully unprepared*. (P5)

I'm having to learn stuff to try and teach it... I'm trying to understand why they need to learn those things so that I can explain to them why they need to learn those things. (P4)

There are areas that I'm not an expert in. So I had to read quite a bit about these things. *I had to educate myself*, and I had to update myself with current research. (P2)

However, the fixed organisational structures in place were emphasised as limiting their ability to lead interdisciplinary courses.

Sometimes interdisciplinarity is not as interdisciplinary as we think it is... *the institutional setup is not quite set up to promote interdisciplinarity*. (P4)

Central to this category was course leaders' emphasis on the challenges of working within fixed disciplinary structures while developing and sustaining interdisciplinary courses. They described their experiences as being more difficult and stressful than leading disciplinary courses. They further emphasised the need to seek out networks of support, to self-identify, and to self-direct their own learning and expressed concerns over both the

quality of the resulting courses and the sustainability of the networks that supported their educational practices.

Category B: Resistant to Change

In Category B, course leaders expressed their experiences of institutional environments as overcoming existing disciplinary structures. However, they emphasised the difficulty in sustaining their efforts, characterising the institutional environment as resistant to change. Developing innovative interdisciplinary courses and getting them accepted by the university was not straightforward.

She came back to the university with the vision and mission to support innovation in science. [She] and two other people started it... We submitted the grant... [and] got it funded. *It ran as a co-curricular activity only, then as a course.* (P17)

Course leaders described benefiting from institutional initiatives that encouraged collegial collaboration but also identified how changes in institutional leadership negatively impacted the sustainability of courses and collaborations.

At that time, I didn't have any relationships with other schools. But *the faculty was doing this matchmaking exercise* of having [academics] from different schools get together. We initiated some conversations... and they became very important. (P8)

Sustainability is a challenge. So for example... we're no longer collaborating with [paired discipline]. *They* changed the coordinator, and this person's working with another partner now... It's a challenge to find an alternative this year. (P23)

Course leaders noted receiving resourcing for the development of interdisciplinary courses but expressed that it was insufficient to support collaborative design processes.

We were given one year with a small budget... Having whole group meetings where everybody can escape from their everyday responsibility to really have an in-depth conversation was not easy. So we *weren't able to run those kinds of... really developed processes.* (P15)

The development of expertise was again expressed as being self-directed and benefiting from available collegial support; however, in this category, expertise external to the university was sought out.

I started to do my own research. I went through different *research papers and curricula from other universities*. (P7)

I did a little bit of a sort of *special studies leave*. I went to Harvard for a week or so, and then I did a bit of a whistle-stop tour around Europe, talking to people about how they teach, what worked well, and what were some of the bigger innovations. (P10)

Course leaders emphasised that organisational structures were inconducive to sustaining interdisciplinary courses. Following the development of interdisciplinary courses, course leaders faced ongoing issues due to an inflexibility in their institutional environment.

The university *is not set up to support an interdisciplinary course* ... Unless there are people carrying it and not giving up, there is a risk that these things can die because *they're not supported by governance structures and an underlying financial model*. They're not business-as-usual courses. (P17)

We're pushing against a very strong current and the only way to do that is *to push hard and consistently*... but by implementing it in a way that keeps the current practices in place, we're subverting the intention of the reform. (P22)

This category was characterised by course leaders' descriptions of conducting extra work and to sustain the innovative interdisciplinary courses they developed. Simply put, developing innovative courses were resourced to different degrees, but course leaders worked around structures in the institutional environment but did not attempt to change it, making it difficult for course leaders to sustain interdisciplinary courses and their educational practices.

Category C: Adaptable

In Category C, institutional environments were experienced as being open to adaptation. In this category, course leaders placed a greater emphasis on sustaining interdisciplinary courses. Course leaders noted enacting subtle adaptations to institutional environments on a case-by-case basis to improve upon their recurring educational practices.

Course leaders emphasised the need to both create and sustain social infrastructure to support ongoing interdisciplinary educational practices.

These interdisciplinary approaches... When I arrived, I couldn't really see the kind of infrastructure or environment. So *I had to start to build really from scratch, the collaboration and network with different colleagues* from other faculties. (P17)

These things are very time-consuming... so I told our Associate Head of Education that this is the time dedicated by these people for this. So *it's important that moving forward, that becomes a regular allocation. When we started, none of us actually kept time or track of it.* (P8)

Course leaders described experiences of applying for existing funding and requesting further funding, both of which were not limited to supporting the development of courses. This included resourcing for collaboration between course leaders, and the allocation of physical infrastructure to support interdisciplinary teaching and learning.

It was not an ordinary course. I think that when [*university leadership*] *offered this grant... It was meant to open up more interdisciplinary opportunities* between staff members. (P15)

We asked for money to be able to have 5-10 new configurations... and *we got funding from them* to buy the instruments. (P8)

In this category, the development of expertise shifted from self-directed and self-regulated learning to strategic learning with and from university colleagues, especially in relation to developing educational design expertise. This included expert mentors offering facilitation and real-time feedback in ongoing educational design activity.

So there's someone in educational innovation who has been supporting my educational design work for five or six years. So whenever I have a problem, I go to her. (P12)

Ideally, you work with mentors who show you how they design and how they think about what they're doing. (P12)

Once again, course leaders described challenges in navigating organisational structures, however, in this category they described their inability to conduct research on their interdisciplinary design practices due to the excessive workloads they faced when leading interdisciplinary courses. However, they emphasised the importance of making their practices visible.

Unfortunately, *the work part of the job got so heavy* that *the fun part* which is actually researching it didn't happen. (P23)

It's all of that curriculum development, and curriculum refinement, and *all of that stuff that's not captured in our workload models* or understood by the decision-makers who don't have *visibility* over this type of work. (P23)

In this category, course leaders described practical ways of adapting the institutional environment to better support interdisciplinary design practices and identified other practices that required research to make them more visible to university leadership. Whereas in prior categories there was a focus on identifying and, at times, overcoming the challenges faced when developing interdisciplinary courses, in Category C, there was a focus on individuals both enacting and proposing further changes to the institutional environment.

Category D: Restructured

In this final category, aspects of the institutional environment were described as having been restructured to facilitate the institutionalisation of some interdisciplinary courses, an action that was informed by the findings from formal curriculum reviews.

It's part of the restructuring of the curriculum. (P1)

However, course leaders described the institutionalisation of interdisciplinary courses as requiring further stakeholder involvement. Course leaders described a lack of established social networks across schools and faculties leading to issues in the acceptance of the institutionally-led changes. Additionally, course leaders emphasised that there were challenges in sustaining interdisciplinary courses due to a lack of familiarity between those developing courses and the academics who subsequently led the courses in later iterations or enactments.

When they were trying to cross the faculty boundaries, it was not straightforward. It wasn't very welcomed by schools or faculties. (P15)

So the second year they got someone else who wasn't involved in the conception of [the course], and didn't... well, they just taught a course on how to work together... So *it went away from scaffolding students through a process of discovery and creation to just, "here's the process". This is the rule, not the exception.* (P13)

However, in this category, resourcing was not identified as an issue. The development of courses was considered to be sufficiently resourced.

In terms of the design work that was done, it was very well resourced and supported. (P16)

Additionally, course leaders described the provision of formal learning opportunities. However, they described learning opportunities in terms of formal training and at times critiqued the quality of the training offered to them:

There's always plenty to learn... I try to keep on top of the opportunities that are offered to us, from the University and from the faculty but it's not easy. Sometimes I wish I had more time. (P1)

I don't think the [interdisciplinary] workshops are useful... they're not being led by experts in the area. (P19)

In this category, course leaders described their experiences in relation to the institutionalisation of interdisciplinary courses that restructured the institutional environment. They identified significant institutional resourcing, education, and support but the institutionally-led change as enacted for them, not with them. They also identified issues with the communication, sustainability, and quality of the institutionalised courses.

Relationships between the categories

The relationships between the four categories of description were most apparent when explored via the four dimensions of variation (Table 2). The dimensions of variation did not neatly map to the ACAD wireframe. Course leaders focused primarily on aspects of social design (organisational structures and social infrastructures) and epistemic design

(stakeholders' development of expertise). Course leaders' also emphasised the role of resourcing and its relationship to their availability to conduct interdisciplinary design work.

In Dimension 1, social infrastructure, course leaders expressed the need for collaborations and other social arrangements to support their interdisciplinary design practices. In Category A, course leaders emphasised the need to seek out informal networks of support, In Category B, they described how institutional support for networking helped them but identified some challenges. Then, in Category C, course leaders noted that they established and sustained their own informal networks of support. In Category D, course leaders described the institutionalisation of design, noting the use of professional design teams that they were not a part of socially. . This contrasts with the first three categories, where course leaders expressed a heavy reliance upon informal networks of support.

In Dimension 2, resourcing, course leaders expressed their experiences of creating and sustaining interdisciplinary courses as resource-intensive and noted different responses to their need for resourcing. Course leaders expressed having no resourcing beyond the common teaching duty allocation of time, limiting what they could achieve in Category A, having some resourcing but not enough to conduct thorough design processes in Category B, and seeking out further funding to address shortfalls in Category C. Only in Category D did course leaders note that design processes were well-resourced.

In Dimension 3, the development of expertise, course leaders emphasised ongoing learning, developing interdisciplinary design expertise in different ways. In Categories A and B, they expressed a reliance on informal networks of support in addition to self-determined and self-directed learning, and in Category B, also noted drawing upon the curricula and practices of other universities. In Categories C and D, they emphasised having significant support, including sustained mentorship from experts from informal collegial networks in

Category C. However, in Category D, they described formalised training provided by the university but critiqued its quality.

In Dimension 4, organisational structures, course leaders expressed how they experienced the organisational structures to support the development and sustainability of interdisciplinary courses. In Categories A and B, course leaders described organisational structures as not conducive or hard to change, and in Category C as open to adaptation or change. Simultaneously, in Category A, course leaders noted working within existing structures whereas in Category B they described working around them, in Category C they described adapted them, and in Category D they described them as being restructured, but not having agency in the restructuring.

Investigation of the relationships between the four categories via exploration of the dimensions of variation shows course leaders' incremental awareness of their agency in different dimensions of variation when they describe their experiences of the institutional environment. This includes awareness of the need and potential for collegial support starting in Category A; the potential to get further resourcing for course development starting in Category B; the benefits of collegial networks and formal training for ongoing learning to develop their expertise starting in Category C; and on the potential to adapt or restructure the institutional environment starting in Category C as well. Prior to these areas of awareness of their agency (shaded parts of the outcome space in Table 2), course leaders experiences were characterised by working within the existing environment with limited agency to modify it.

Overall, across Categories A to C, course leaders increasingly emphasise their agency and collective capacity to shape the institutional environment, and, in Category D, this emphasis shifts to the agency of the institution. In the latter category, course leaders experience the institutional environment as already reorganised. While they experience various limitations in how this new institutional environment is organised and function to

support interdisciplinary education, they emphasise having limited agency to change these arrangements.

Discussion

This study reports on four qualitatively different ways that interdisciplinary course leaders experience their institutional environments when developing and sustaining interdisciplinary courses. Whereas a body of research exists on the challenges faced by academics when embedding interdisciplinary education within universities (Lyll et al., 2015; Lindvig et al., 2019; Cai & Lönnqvist, 2022), our study goes further, simultaneously showing the challenges course leaders face and the ways they address them. It makes three distinct contributions to the domain of interdisciplinary education.

First, our outcomes show how interdisciplinary course leaders experience and cope with resourcing challenges when developing and sustaining interdisciplinary courses. Specifically, in Categories A, B, and C, course leaders experience insufficient resourcing but are agentic and engaged in seeking resources to develop and sustain interdisciplinary courses. These categories align with descriptions of interdisciplinary education as being resource-intensive (Holley & Szostak, 2022; Lyll et al., 2016). They also are indicative of a tendency for universities to focus on innovation over the sustainability of courses and is characteristic of a contagion model of change where new initiatives are funded and turned into exemplars of best practices to be adopted by others which rarely lead to significant changes in the system (Ashwin, 2020; Trowler et al., 2014). In Category D, however, course leaders experience a well-funded environment that is specifically organised to support and sustain interdisciplinary education. However, they experience this environment as something being created by others and feel detached from shaping it. This finding suggests that the resourcing and institutionalisation of interdisciplinary education do not automatically result in an institutional environment conducive to engagement and innovation in interdisciplinary

education. In fact, course leaders in such an environment could feel less empowered to make a difference.

Second, our outcomes show a wide variation in how interdisciplinary expertise is developed, much of which relies on self-study and collaborative approaches to learning in the informal collegial networks that course leaders seek out, develop, and sustain. Lyall et al. (2016) have recommended leveraging the knowledge and expertise of ‘motivated individuals’ responsible for innovations in interdisciplinary provision to generate a body of good practice that can be used by practitioners to develop relevant expertise through institutionally-provided courses or masterclasses. While the provision of workshops and one-off professional development was common in Category D, the majority of professional development was self-initiated and self-directed (in Categories A and B) or developed through ongoing mentorship and collaboration (in Category C). Overall, our outcomes show that valued experiences for developing interdisciplinary design expertise are largely characterised by informal and social learning in ongoing design activity and a shift to similarly valued institutionally-provided professional development could be a challenging step.

Third, our outcomes show that course leaders can have significant agency in addressing and adapting social and organisational infrastructures when developing and sustaining interdisciplinary courses. Cai and Lönnqvist (2022) have argued that interdisciplinary educational practices rarely change university structures, and Vienni Baptista et al. (2022) have argued that ‘piecemeal’ approaches to changing environments have limited potential to support and sustain interdisciplinary education. Our outcomes provide more nuanced insights into how change happens and what impact changes can have on the institutional environment. They suggest that course leaders’ practices do have the potential to make change within institutional environments, and that ‘piecemeal’ adaptations

and advocacy could shape institutional environment in meaningful situationally-specific ways. Overall, our findings are more in line with Holley and Szostak's (2022) assertion that interdisciplinary transformation can significantly impact institutional environments just over longer periods of time. However, such transformations do not necessarily automatically result in an environment that is experienced as being dynamic and conducive for innovation.

Conclusions

Our study presents a spectrum of ways that course leaders experience their institutional environment when developing and sustaining interdisciplinary courses. It explores interdisciplinary course leaders' accounts of their experiences, but does not study their actual practices. In doing so, it provides limited insight into the nuances of practices, but instead shows a breadth and variations in collective experiences. Our outcomes have three significant implications for the study of interdisciplinary education.

First, our outcomes show that course leaders not only shape the courses they lead but simultaneously shape the environment they inhabit, to include resourcing of courses, social support infrastructures, professional development, and organisational structures. This indicates that a primary focus on the pedagogical course design aspects in research on interdisciplinary education is insufficient to understand practices involved in developing and sustaining interdisciplinary education and that ecological research approaches may be better suited to studying interdisciplinary education in context.

Second, our study challenges the common belief about the benefits of a whole institution approach and deliberate creation of special organisational structures for interdisciplinary education (Lyll et al., 2016). While the course leaders emphasised the desire for higher-level institutional leadership and support, they simultaneously felt disempowered and sceptical about high-level institutional initiatives. This indicates that overhauls of university systems may not be necessary and shaping the institutional

environment through small, bottom-up ongoing changes in practice should not be dismissed as necessarily ineffectual.

Third, our outcomes show that course leaders do have agency in changing their institutional environments. Framing research in terms of identifying challenges to interdisciplinary educational practices reinforces the concept that institutional environments are fixed and external to the practices of course leaders, overlooking course leaders' roles in shaping their environment.

Overall, our outcomes suggest that interdisciplinary education might be better conceived of as an integral and evolving part of university education, not as a supplement to discipline-based educational practices. In this way, the role of interdisciplinary education within the institutional environment can be viewed as relational, wherein practices are shaped by and, in turn, have the power to shape an institutional environment.

Acknowledgment

This research was partly funded by the Australian Research Council through Discovery Project grant DP200100376 (Developing interdisciplinary expertise in universities).

Data availability statement

The participants of this study did not give written consent for their data to be shared publicly, so due to the sensitive nature of the research supporting data is not available.

References

- Åkerlind, G. S. (2012). Variation and commonality in phenomenographic research methods. *Higher Education Research and Development*, 31(1), 115–127.
<https://doi.org/10.1080/07294360.2011.642845>
- Åkerlind, G. S. (2024). Common misunderstandings of phenomenographic research in higher education. *Higher Education Research and Development*, 43(1), 1–16.
<https://doi.org/10.1080/07294360.2023.2218804>

- Aldrich, J. H. (2014). *Interdisciplinarity: Its role in a discipline-based academy*. Oxford University Press.
- Ashwin, P. (2020). *Transforming university education: A manifesto*. Bloomsbury.
- Bowden, J. A., & Green, P. (Eds.). (2005). *Doing developmental phenomenography*. RMIT University Press.
- Brew, A. (2007). Disciplinary and interdisciplinary affiliations of experienced researchers. *Higher Education* 56(4), 423–38. <https://doi.org/10.1007/s10734-007-9102-4>.
- Brew, A., Boud, D., Lucas, L., & Crawford, K. (2022). Hampering teaching excellence? Academics making decisions in the face of contradictions. *Studies in Higher Education*, 47(4), 941–952. <https://doi.org/10.1080/03075079.2020.1828327>
- Cai, Y., & Lönnqvist, A. (2022). Overcoming the barriers to establishing interdisciplinary degree programmes: The perspective of managing organisational innovation. *Higher Education Policy*, 35(4), 946–968. <https://doi.org/10.1057/s41307-021-00242-0>
- DeZure, D. (2017). Interdisciplinary pedagogies in higher education. In R. Frodeman (Ed.), *The Oxford handbook of interdisciplinarity* (2nd ed., pp.558–572). Oxford University Press. <https://doi.org/10.1093/oxfordhb/9780198733522.013.45>
- Ellis, R. A., & Goodyear, P. (2019). *The education ecology of universities: Integrating learning, strategy and the academy*. Routledge. <https://doi.org/10.4324/9781351135863>
- Franks, D., Dale, P., Hindmarsh, R., Fellows, C., Buckridge, M., & Cybinski, P. (2007). Interdisciplinary foundations: Reflecting on interdisciplinarity and three decades of teaching and research at Griffith University, Australia. *Studies in Higher Education*, 32(2), 167–185. <https://doi.org/10.1080/03075070701267228>
- 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>
- Han, F., & Ellis, R. A. (2019). Using phenomenography to tackle key challenges in science education. *Frontiers in Psychology*, 10, 1414. <https://doi.org/10.3389/fpsyg.2019.01414>
- Holley, K. A. (2009). The challenge of an interdisciplinary curriculum: A cultural analysis of a doctoral-degree program in neuroscience. *Higher Education*, 58(2), 241–255. <https://doi.org/10.1007/s10734-008-9193-6>

- Holley, K. A., & Szostak, R. (2022). Interdisciplinary education and research in North America. In Vienni Baptista, B., & Klein, J. T. (Eds.), *Institutionalizing Interdisciplinarity and transdisciplinarity* (Vol. 1, pp. 72–86). Routledge.
<https://doi.org/10.4324/9781003129424-7>
- Klein, J. T. (2010). *Creating campus cultures. A model for strength and sustainability*. Jossey-Bass and Association of American Colleges and Universities.
- Lindvig, K. (2023). Loud and soft voices of interdisciplinarity in higher education. In T. Øland, S. Sauzet, M. L. Ryberg, & K. Lindvig (Eds.), *Configurations of interdisciplinarity within education: Danish experiences in a global educational space* (pp. 94–118). Routledge. <https://doi.org/10.4324/9781003083245-5>
- Lindvig, K., Lyall, C., & Meagher, L. R. (2019). Creating interdisciplinary education within monodisciplinary structures: The art of managing interstitiality. *Studies in Higher Education*, 44(2), 347–360. <https://doi.org/10.1080/03075079.2017.1365358>
- Lindvig, K., & Ulriksen, L. (2019). Different, difficult, and local: A review of interdisciplinary teaching activities. *The Review of Higher Education*, 43(2), 697–725. <https://doi.org/10.1353/rhe.2019.0115>
- Lyall, C., Meagher, L., Bandola, J., & Kettle, A. (2016). *Interdisciplinary provision in higher education: Current and future challenges*. Higher Education Academy.
<https://documents.advance-he.ac.uk/download/file/document/4604>
- Marton, F. (1986). Phenomenography—A research approach to investigating different understandings of reality. *Journal of Thought*, 21(3), 28–49.
- Marton, F., & Booth, S. (2013). *Learning and awareness*. Taylor & Francis.
<https://doi.org/10.4324/9780203053690>
- Øland, T., Sauzet, S., Ryberg, M. L., & Lindvig, K. (2023). *Configurations of interdisciplinarity within education: Danish experiences in a global educational space*. Routledge. <https://doi.org/10.4324/9781003083245>
- Pohl, C. (2022) [Foreword]. In Vienni Baptista, B., & Klein, J. T. (Eds.), *Institutionalizing Interdisciplinarity and transdisciplinarity* (Vol. 1, pp. xx–xxii). Routledge.
<https://doi.org/10.4324/9781003129424>
- Ryberg, M. L., Øland, T., Lindvig, K., & Sauzet, S. (2023). Introduction: Configurations of interdisciplinarity across the educational system. In Øland, T., Sauzet, S., Ryberg, M.L., & Lindvig, K. (Eds.), *Configurations of Interdisciplinarity within education: Danish experiences in a global educational space* (Vol. 1, pp. 1–21). Routledge.
<https://doi.org/10.4324/9781003083245-1>

- Sauzet, S. (2023). Interdisciplinarity in the University Colleges: Versions of interprofessional responsibility. In Øland, T., Sauzet, S., Ryberg, M.L., & Lindvig, K. (Eds.), *Configurations of interdisciplinarity within education: Danish experiences in a global educational space* (Vol. 1, pp. 69–93). Routledge.
<https://doi.org/10.4324/9781003083245-4>
- Trowler, P. (2020). *Accomplishing change in teaching and learning regimes: Higher education and the practice sensibility*. Oxford University Press.
- Trowler, P., Ashwin, P. and Saunders, M. (2014). *The Role of HEFCE in Teaching and Learning Enhancement: A Review of Evaluative Evidence*. Higher Education Academy.
- Turner, R., Cotton, D., Morrison, D., & Kneale, P. (2022). Embedding interdisciplinary learning into the first-year undergraduate curriculum: Drivers and barriers in a cross-institutional enhancement project. *Teaching in Higher Education*, 29(4), 1092–1108.
<https://doi.org/10.1080/13562517.2022.2056834>
- Vienni Baptista, B., Klein, J. T., & Streck, D. (2022). Conclusion: A comparative framework for institutionalizing inter- and trans-disciplinary research and teaching in higher education. In Vienni Baptista, B., & Klein, J. T. (Eds.), *Institutionalizing Interdisciplinarity and transdisciplinarity* (Vol. 1, pp. 232–248). Routledge.
<https://doi.org/10.4324/9781003129424-19>

Chapter 9: Discussion

This chapter begins by recounting the study's research questions, then presents a summary of the discussion points and the implications of each of the five articles on research and practice (Chapters 4–8). This is followed by a synthesis of the outcomes from the five chapters and the overall contribution of this thesis to research on designing for interdisciplinary teaching and learning in higher education.

This study answers the overarching research question, *How do course leaders experience designing for interdisciplinary teaching and learning in higher education?* To answer this overarching question, this thesis investigated five specific research questions, each reported in a separate journal article:

1. How do leaders of interdisciplinary courses understand interdisciplinarity?
2. How do interdisciplinary course leaders conceive of the purpose of interdisciplinary education?
3. How do course leaders approach teaching and learning when designing interdisciplinary courses?
4. How do course leaders experience educational design processes when developing interdisciplinary courses?
5. How do course leaders experience their institutional environments when developing and sustaining interdisciplinary courses?

9.1 Summary of the Main Outcomes

The following five sections summarise the outcomes of the articles in this thesis. They report on the investigation of the five different areas of inquiry regarding course leaders' experiences of designing for interdisciplinary teaching and learning.

9.1.1 How do leaders of interdisciplinary courses understand interdisciplinarity?

In this chapter, course leaders understood interdisciplinarity in three qualitatively different ways, across three dimensions of variation (Table 9.1.1). Participants' understandings of interdisciplinarity reflected definitions and stances common in the literature but did not adopt any single definition outright. Instead, understandings diverged significantly from normative understandings, often challenging them. Course leaders' understandings did not simply build upon, combine, or extend upon common understandings found in the literature. Instead, course leaders constructed their own unique, individual understandings through sensemaking and reflections upon their interdisciplinary experiences, manifesting in multiple, sometimes entangled ways of understanding interdisciplinarity.

Further, understandings in the three categories of description aligned with distinct epistemological positions that advanced from rationalist (Category A) to constructivist (Category B) to pragmatist (Category C) positions. As course leaders' understandings became more complex advancing from Category A to C, they became more grounded in problem-centred experiences and were also associated with an increasing level of epistemic confidence (greater epistemic agency).

Table 9.1.1

Summary of Outcomes: How do leaders of interdisciplinary courses understand interdisciplinarity?

<i>Research Question</i>	<i>Categories of Description</i>	<i>Dimensions of Variation</i>
How do leaders of interdisciplinary courses understand interdisciplinarity?	A) Definitions B) Knowledge spaces C) Knowledge work	1) Conceptions 2) Language used 3) Formation of understanding

Main contributions and implications

These outcomes show that interdisciplinary experiences and familiarity with the literature alone do not lead to more comprehensive understandings of interdisciplinarity. A sole focus on experiences and definitions could potentially limit the development of a broader and deeper understanding of interdisciplinarity. Furthermore, course leaders shifted between different ways of understanding interdisciplinarity and, therefore, shifted between different epistemological stances when articulating their understandings of interdisciplinarity.

These outcomes challenge the assumption in the literature that non-normative understandings are misunderstandings or confusions. Our outcomes show that variation in understandings *across* course leaders is common, and that variation in understanding *within* course leaders is also common. This indicates the need for course leaders to be explicit about what they mean when they talk about interdisciplinarity and the need for course leaders and university leadership to develop either agreed-upon understandings or accept multiple mutually acknowledged understandings in practice.

9.1.2 How do interdisciplinary course leaders conceive of the purpose of interdisciplinary education?

In this chapter, course leaders conceived of the purpose of interdisciplinary education in five qualitatively different ways, across four dimensions of variation (Table 9.1.2). The outcomes show that interdisciplinary education can play a critical role in developing and enriching students' disciplinary understandings and practices, showing a constitutive relationship between disciplinary and interdisciplinary education, not a dichotomous relationship. Further, course leaders described interdisciplinary integration in two main ways: in relation to integrating perspectives, and in relation to integrating the knowledge, methods, and tools of different disciplines. The first three categories reflected the integration of perspectives and

were characteristic of instrumental, outcome-oriented purposes of interdisciplinary education, whereas the last two categories reflected integration in knowledge work and were characteristic of transformative purposes of interdisciplinary education: purposes that rarely feature in the literature on undergraduate education.

Table 9.1.2

Summary of Outcomes: How do interdisciplinary course leaders conceive of the purpose of interdisciplinary education?

<i>Research Question</i>	<i>Categories of Description</i>	<i>Dimensions of Variation</i>
How do interdisciplinary course leaders conceive of the purpose of interdisciplinary education?	A) Enrichment-oriented B) Employability-oriented C) Integration-oriented D) Epistemically-oriented E) Society-oriented	1) Capabilities 2) Activities 3) Framings 4) Motives

Main contributions and implications

In the literature on higher education, the role of knowledge is often underemphasised in comparison with the significant focus placed upon the development of students' interdisciplinary skills in common discourse. The outcomes in this chapter show that in addition to focusing on the development of students and their individual skills, course leaders also conceptualise the purpose of interdisciplinary education as developing students' capabilities to work with knowledge. Course leaders' conceptions of purpose therefore do not fall neatly into any one category as their conceptions of purpose may align with multiple aspects of a university's mission. These outcomes indicate that there is a need for course leaders to be explicit about their conceptions of purpose because there can be significant variation in purposes which can be both entangled and situated within local practices. Being explicit about purposes can help course leaders to be strategic in their aims when designing for interdisciplinary teaching and learning.

9.1.3 How do course leaders approach teaching and learning when designing interdisciplinary courses?

In this chapter, course leaders approached interdisciplinary teaching and learning in four qualitatively different ways, across six dimensions of variation; two related to social aspects of design, two related to epistemic aspects of design, and two related to physical aspects of design (Table 9.1.3). Phenomenographic studies on teaching and learning conducted in disciplinary contexts report variation in approaches advancing from teacher-centred approaches to more comprehensive student-centred approaches. Our outcomes show that approaches to interdisciplinary teaching and learning advance from being centred on students' experiences and autonomy, to approaches that centre on students' engagement in knowledge-creation practices. In contrast to previous research in disciplinary contexts, these more comprehensive approaches to interdisciplinary teaching include explicit teaching and scaffolding strategies to support the development of students' epistemic agency. Our outcomes further highlight the role of physical aspects of design for interdisciplinary teaching and learning, showing that an awareness of spaces, materials, and technologies to support students' interdisciplinary knowledge creation are associated with more complex and comprehensive approaches to interdisciplinary teaching and learning in course designs.

Table 9.1.3

Summary of Outcomes: How do course leaders approach teaching and learning when designing interdisciplinary courses?

<i>Research Question</i>	<i>Categories of Description</i>	<i>Dimensions of Variation</i>
How do course leaders approach teaching and learning when designing interdisciplinary courses?	A) Experience-centred B) Autonomy-centred C) Inquiry-centred D) Epistemic Agency-centred	1) Roles of teachers 2) Roles of learners 3) Student needs 4) Pedagogical strategies 5) Physical spaces 6) Technology use

Main contributions and implications

Our outcomes show that approaches to interdisciplinary teaching and learning associated with the development of students' capabilities for knowledge work employ explicit instruction and scaffolding strategies in addition to student-centred teaching and learning. These strategies were often used to address the complexity and challenges of interdisciplinary knowledge work. Our outcomes highlight the differences between *autonomy (choice)*, students' *agency* regarding how they work in teams and conduct project work, and *epistemic agency* regarding how they work with different knowledges and participate in epistemic practices during interdisciplinary teamwork. This chapter therefore contributes an interdisciplinary focus to a body of research on approaches to teaching and learning in higher education.

9.1.4 How do course leaders experience educational design processes when developing interdisciplinary courses?

In this chapter, course leaders experienced interdisciplinary educational design processes in four qualitatively different ways across six dimensions of variation, including two that were associated with social aspects of design processes, two that were associated with physical aspects of design processes, and two that were associated with epistemic aspects of design processes (Table 9.1.4). Interdisciplinary course design processes were commonly experienced collaboratively. Course leaders described seeking out, establishing, and sustaining informal communities and networks of colleagues to support their design work. This chapter also shows that while environments can impact interdisciplinary educational design processes, environments can also be configured to support interdisciplinary educational design processes. In this chapter as well, course leaders showed a greater awareness of spaces, materials, and technologies that were associated with complex, comprehensive design processes.

Table 9.1.4

Summary of Outcomes: How do course leaders experience educational design processes when developing interdisciplinary courses?

<i>Research Question</i>	<i>Categories of Description</i>	<i>Dimensions of Variation</i>
How do course leaders experience educational design processes when developing interdisciplinary courses?	A) Ad hoc and on the run B) Modification C) Dialogic co-creation D) Design as inquiry	1) Design agency 2) Social structures 3) Technologies 4) Spaces 5) Design strategy 6) Design knowledge

Main contributions and implications

Course leaders experienced interdisciplinary design processes collaboratively, supported through institutional means and the informal assistance of collegial networks. Furthermore, course leaders emphasised a need for further research on design for interdisciplinary teaching and learning practices to generate knowledge that can help course leaders with the complexity of the processes of designing for interdisciplinary teaching and learning.

9.1.5 How do course leaders experience their institutional environments when developing and sustaining interdisciplinary courses?

In this chapter, when developing and sustaining interdisciplinary courses, course leaders experienced their institutional environments in four qualitatively different ways across four dimensions of variation (Table 9.1.5). This chapter identifies the challenges they faced when developing and sustaining interdisciplinary courses and describes how course leaders responded to the challenges they faced. The first two ways of experiencing the institutional environment were characterised by working within constraints, necessitating excessive individual effort to develop and sustain interdisciplinary courses. The latter two ways of experiencing it viewed the institutional environment as open to change. The study's outcomes

show that interdisciplinary course leaders' practices are shaped by their institutional environment, and that course leaders, in turn, can have some agency to shape their institutional environment. However, change happens in manifold, incremental ways that shape practices over time, not through large transformations. Furthermore, these outcomes question the extent to which pedagogical innovations have the potential to shape interdisciplinary education.

Table 9.1.5

Summary of Outcomes: How do course leaders experience their institutional environments when developing and sustaining interdisciplinary courses?

<i>Research Questions</i>	<i>Categories of Description</i>	<i>Dimensions of Variation</i>
How do course leaders experience their institutional environments when developing and sustaining interdisciplinary courses?	A) Fixed B) Resistant to change C) Adaptable D) Restructured	1) Social Infrastructure 2) Resourcing 3) Development of Expertise 4) Organisational Structures

Main contributions and implications

Our study indicates that there is a need in research on design for interdisciplinary teaching and learning to focus beyond pedagogy. In addition to investigating pedagogical innovations, there is a need to conduct more research on the practices involved in developing and sustaining interdisciplinary education, including how course leaders navigate and shape their institutional environment. Ecological research approaches can be helpful as they are well-suited to studying interdisciplinary education in ways that are considerate of the institutional setting and structures.

Further, this chapter challenges the common belief that a whole-institution approach, including the creation of special organisational structures to support interdisciplinary

education, is required to advance interdisciplinary education. The outcomes indicate shaping the institutional environment through small, bottom-up, ongoing changes in practice should not be dismissed as insignificant or ineffectual. Furthermore, too great a focus in research centred on identifying challenges to interdisciplinary educational practices can reinforce the concept that institutional environments are fixed, overlooking course leaders' roles in shaping their institutional environment. Viewing design for interdisciplinary teaching and learning as relational (it is influenced by and influences the institutional environment) can help raise course leaders' awareness of their agency to advance interdisciplinary education and to shape the institutional environment in which their practices are situated.

9.2 Synthesis of Outcomes

This section presents ways that course leaders experienced designing for interdisciplinary teaching and learning drawn from synthesising the outcomes of the five articles and exploring the relationships between them. Each of the five articles presents a spectrum of variation that describes how course leaders experienced some aspect of designing for interdisciplinary teaching and learning. This section discusses the contributions of the synthesised outcomes to the existing body of research on designing for interdisciplinary teaching and learning. It also comments on some of their implications.

This section begins by presenting the contributions the thesis makes to knowledge on designing for interdisciplinary teaching and learning. It begins by discussing novel outcomes, including how course designers' experiences were characterised in six ways, as: collaborative, knowledge work, involving ongoing learning, situated, plural, and challenging. It then discusses how these outcomes extend research on design for interdisciplinary teaching and learning.

Collaborative

The outcomes from the five chapters together show that course leaders almost exclusively experience designing for interdisciplinary teaching and learning collaboratively.

Collaboration in design for interdisciplinary teaching and learning is common; however, in this study, it is a defining characteristic of course leaders' experiences. This contrasts with university leaders' descriptions of course leadership in the literature, which acknowledge collaboration but tend to foreground the role of enterprising individuals in driving interdisciplinary education (Lyall et al., 2016; Lindvig et al., 2019). The outcomes in the five studies show course leaders' reliance upon collegial networks to support their design practices and the development of their interdisciplinary expertise. Enterprising individuals may drive interdisciplinary education; however, it is important to note that design for interdisciplinary teaching and learning is not a solitary experience but is experienced almost exclusively in collaboration with others.

There are multiple examples that demonstrate the collaborative nature of interdisciplinary design experiences in the chapters. In Chapter 4, understandings of interdisciplinarity were developed through informal collegial discussions in the *Definitions* Category and informal mentorship in the *Knowledge Spaces* Category, and collaboratively constructed in the *Knowledge Work* Category. In Chapter 7, collaboration was described as an aspect of all categories. For example, collegial support was sought out from informal networks in the *Ad-hoc-and-on-the-run* Category, collaboration involving resource sharing, discussions, and advice were central to the *Modification* Category, collaborative processes were developed, sustained, and practiced in the *Dialogic co-creation* Category, and collaboration was central to ways of working with experts, students, and other stakeholders in participatory design research processes in the *Design as inquiry* Category. In Chapter 8, collaboration and support were sought out and relied upon in the *Fixed* Category,

relationships and leadership in teams were emphasised in the *Resistant to change* Category, institutionally supported networking to develop ongoing collaboration and reliance upon mentors in informal networks was emphasised in the *Adaptable Category*, and institutional support and collaborative initiatives were common in the *Restructured Category*.

It has been argued that as the scope, complexity, and sophistication of design tasks increase, there is a need for greater collaboration and larger design teams (Goodyear & Ellis, 2019; McKenney et al., 2015). The outcomes reported across the five chapters showed that designing for interdisciplinary teaching and learning was complex and challenging, so unsurprisingly, course leaders consistently sought out, established, and maintained collegial networks to support their interdisciplinary design work. However, it is important to clarify that while all course leaders experienced designing collaboratively, course leaders' experiences of collaborating varied, from working on course designs in serial fashion to employing design thinking methodologies, to conducting collaborative research in design processes to generate design knowledge. Collaboration is central to all course leaders' experiences, but course leaders did not describe standard ways of collaborating.

Knowledge work

The outcomes also showed that course leaders often experienced designing for interdisciplinary teaching and learning as knowledge work. The outcomes from multiple chapters show that designing for interdisciplinary teaching and learning is not limited to teaching-related responsibilities but may include conducting inquiry, working with different knowledge practices, and generating design knowledge in service of course development and sustainability. Markauskaite (2020) describes interdisciplinary knowledge work as a space where “diverse knowledge practices, tools, and objects intersect and dynamically co-evolve” (p. 112). Course leaders emphasised the challenges they faced with learning how to work

with knowledge, not only for their students, but for their design practices for interdisciplinary teaching and learning as well.

In Chapter 4, course leaders described their understandings of interdisciplinarity in relation to definitions of knowledge practices, in relation to how knowledges interact, and in relation to different ways of working with knowledge when doing interdisciplinary research. In Chapter 7, design processes included the intent to conduct research to generate design knowledge and to inform course designs. Further, in Chapter 8, course leaders described their intent to conduct research to generate useful knowledge that could inform university leadership of their design practices.

In addition to describing their experiences of conducting knowledge work as a component of design practice, course leaders also emphasised the importance of conducting research on their design practices for interdisciplinary teaching and learning to generate useful knowledge. Course leaders emphasised the desire to conduct research that could make their practices *visible* to university leadership to inform decision-making that could shape the institutional environment to better support and sustain interdisciplinary courses and their design practices. Following Manzini (2015), Ellis and Goodyear (2019) refer to this type of knowledge as design knowledge—knowledge that is of practical use to designers. Although the creation of design knowledge was limited, the demand for further guidance and support was expressed, and the importance of evidence-informed practice and the demand for further research were emphasised.

Characterised by ongoing learning

Course leaders described their design experiences as being characterised by ongoing learning. McKenney et al. (2015) claim that educational design work includes developing the capacity to learn to design in novel situations. In the outcomes of this thesis, course leaders'

experiences were characterised by flexibility and the need for ongoing learning related to understanding interdisciplinarity, approaches to interdisciplinary teaching and learning, design processes, and navigating disciplinary institutional structures.

In Chapter 4, ongoing learning included knowledge acquisition, sense-making, conducting inquiry, and knowledge co-creation. In Chapter 7, learning involved conducting primary research to inform designs and learning to design from and together with experts when collaborating. In Chapter 8, this involved learning to navigate institutional structures, to conduct self-directed and self-regulated learning, and to develop capabilities for working with other course leaders when designing. Course leaders also described their experiences as featuring ongoing, flexible learning to develop expertise. In Chapter 7, course leaders learned to design on the fly and manage flexibility in design processes. In Chapter 8, the development of expertise again involved learning to work flexibly within established structures.

It has been suggested that to improve interdisciplinary education, the sharing of exemplars from motivated individuals, the creation of a body of good practice, and the development of individuals' competencies through courses and masterclasses are needed (Lyall et al., 2016). The outcomes show that course leaders developed their understandings, conceptions of purpose, and expertise in ongoing ways in activity, not just in advance of their work. They suggest that how course leaders learn to design involves more than the sharing of exemplars and the development of capabilities in advance of design work. Further research into how interdisciplinary course leaders learn in their design work is therefore needed.

Situated

Research on interdisciplinary teaching has been shown to commonly universalise findings, trading off rich contextual awareness for purposes of increased transferability of research findings (Lindvig & Ulriksen, 2019). This thesis addresses this issue by conducting research

on collective ways of experiencing designing for interdisciplinary teaching and learning within the same institutional setting.

The five outcome spaces in Chapters 4-8 show variation, advancing from less to more comprehensive ways of experiencing designing for interdisciplinary teaching and learning within a shared institutional setting. For example, in Chapter 4, exploration of the variation in understandings of interdisciplinarity generated insights into the epistemological stances of course leaders and their flexibility in working across them. In Chapter 5, the investigation of the relationships between conceptions showed that course leaders viewed interdisciplinary education on a spectrum from instrumental to transformative purposes. In Chapter 6, approaches to interdisciplinary teaching and learning advanced from being student-centred to being knowledge-centred and showed that course leaders viewed interdisciplinary learning in relation to team composition and in relation to ways of working with knowledge.

It is important to state that educational design practices are also situated and vary *within* a shared university setting. Goodyear (2021) argues that "what teachers and teaching teams can do during a design activity is influenced, in subtle and powerful ways, by the social, physical, and epistemic constraints and affordances of the situation in which they are doing that work" (p. 244). The outcomes in this thesis show that course leaders had a range of awareness (from less to more) of their local setting, and a range of awareness of the impact that their environment had upon their experiences of designing for interdisciplinary teaching and learning. The outcomes from this thesis show that course leaders share an institutional setting, but they are not all limited by its constraints; course leaders can have the agency to design their institutional environments to more effectively support their design work. For example, more comprehensive ways of experiencing designing show course leaders engaging in deliberate, informed configuration of design aims, processes, spaces, and strategies.

Plural

Course leaders also described their experiences as plural (multiple or diverse) in nature. This is unsurprising as variation in design work is not only expected but central to interdisciplinary educational design work, which requires working on novel problems within settings that exist to support disciplinary practices. Further, Friesen et al. (2023) argue that "how we design and how we do research in design should not completely converge but sustain plurality" (p. 136). At times, reproduction and repetition were described when course leaders were separated from the creation of courses (e.g., in the Modification Category in Chapter 7), but course leaders commonly experienced designing as flexible practice when they described having agency in their design processes.

In Chapter 4, course leaders' understandings of interdisciplinarity were plural, as were their conceptions of purpose in Chapter 5, being representative of multiple conceptions of the purpose of interdisciplinary education without aligning to any specific conception. In Chapter 6, course leaders' approaches again did not align with any singular approach to interdisciplinary teaching and learning but were representative of different configurations of approaches, ranging from centring on students' experiences and autonomy to the development of their epistemic agency. In Chapter 7, course leaders' design experiences were collaborative, but the ways they collaborated were diverse and configured to the needs of each situation. Lastly, in Chapter 8, course leaders' experiences were associated with multiple categories of experience, showing that the categories of description were not mutually exclusive.

A phenomenographic outcome space represents the qualitatively different ways a phenomenon is experienced, organising them into a hierarchical structure that advances from less to more comprehensive ways of experiencing. Ashwin et al. (2023) state that later categories in an outcome space can be inclusive of earlier categories, noting that "with the

inclusive structure of the hierarchy, any one interview may contain more than one of the categories of description constituted” (p. 1070). This is true of the outcomes presented in this thesis. In multiple chapters, individual course leaders’ experiences of designing did not fall neatly into individual categories but were associated with multiple categories. The outcomes suggest that research should aim to make variation in practices explicit to raise awareness of their plural nature. This can further support the development of mutually acknowledged approaches that can benefit the development of institutional capacity for interdisciplinary educational design. This is in contrast with the tendency in interdisciplinary research to universalise findings (Lindvig & Ulriksen, 2019). The outcomes in this thesis therefore show that interdisciplinary practices are not only multiple or plural; they are also situated, personalised, and constructed. Rather than asking *how* design for interdisciplinary teaching and learning *should* be done, these findings show that it may be better for interdisciplinary course leaders to ask *how* design *could* be done in their local setting to serve intended purposes.

Challenging

Course leaders also expressed their experiences of designing for interdisciplinary teaching and learning as challenging. In the literature, designing for interdisciplinary teaching and learning is commonly described as complex and challenging (Ashby & Exter, 2019; Bopardikar, 2021) and investigations on interdisciplinary design are centred on the challenges that are faced (Cai & Lönnqvist, 2022; Lyall et al., 2016; Turner, 2022). However, presenting empirical outcomes that merely conclude that designing for interdisciplinary teaching and learning is complex contributes little to practice. This thesis therefore reports on some of the *specific challenges* course leaders faced when designing for interdisciplinary teaching and learning, as well as what helped to *enable* course leaders to address the challenges they faced.

In Chapter 4, understanding interdisciplinarity was expressed as hard to know and define, taxonomic terms were described as problematic, and course leaders emphasised the need to learn the meaning and processes of interdisciplinarity to design for interdisciplinary teaching and learning. In Chapter 7, course leaders' challenges included the need to find collaborators and work flexibly to design for non-routine learning activities. Then, in Chapter 8, designing interdisciplinary courses was experienced as difficult, rushed, and anxiety-inducing, and navigating disciplinary structures and sustaining interdisciplinary courses were challenging for course leaders. However, across the chapters, course leaders described their reliance on informal collegial networks to cope with, address, overcome, or eliminate the challenges they faced. In Chapter 8 especially, course leaders focused on ways of adapting their institutional environment to alleviate the challenges they faced in their design practices.

Course leaders who viewed their institutional environment in two ways that impacted their ability to address the challenges they faced: as fixed or as adaptable. Course leaders who viewed their institutional environment as fixed worked within the existing constraints to cope with or overcome challenges. Course leaders who viewed their institutional environment as adaptable took steps to alleviate or eliminate the challenges for themselves and for others. This shows the importance of conducting research on design for interdisciplinary teaching and learning that extends beyond a focus on classrooms to include consideration of wider contextual factors in the institutional environment. It also indicates the need for course leaders' conceptual development to raise awareness of their agency when designing for interdisciplinary teaching and learning; they are not only subject to their institutional environment; they are a part of it and therefore have the power to enact change on it.

Chapter 10: Conclusions

The overall aim of this thesis is to answer the research question: *How do course leaders experience designing for interdisciplinary teaching and learning in higher education?*

Individually, each article in this thesis answers a different aspect of this phenomenon, presenting the variation in qualitatively different ways that course leaders understand, conceptualise, or experience some aspect of the phenomenon of designing for interdisciplinary teaching and learning. Synthesis of the outcomes reported in each of the individual articles generates further insights into understanding this phenomenon as a whole.

This final chapter presents the contributions to knowledge that this thesis makes, the study's limitations, and avenues for future research, before it finishes with concluding remarks.

10.1 Contributions to knowledge

Expanding the scope of designing for interdisciplinary teaching and learning

The outcomes in this thesis indicate that for designing for interdisciplinary teaching and learning, there is a need to expand the conception of who designs, what support is needed, the role of physical aspects of design work, and when design happens.

To begin, there is a need to expand the conception of who designs when designing for interdisciplinary teaching and learning. The outcomes in this thesis show that course leaders experience designing for interdisciplinary teaching and learning almost exclusively collaboratively, even when they are given individual responsibility for design work. Goodyear and Ellis (2019) have argued that solitary approaches to educational design are insufficient and unsustainable when dealing with increased complexity and sophistication. Course leaders characterised designing for teaching and learning as complex and addressed

the complexity of their design work in increasingly sophisticated ways. Designing for interdisciplinary teaching and learning should therefore be viewed as collaborative work and supported accordingly.

The outcomes in this study indicate that support for designing for interdisciplinary teaching and learning extends beyond institutional allocations. Course leaders commonly seek out, form, maintain, and sustain informal networks of collegial support when designing for interdisciplinary teaching and learning. The extent to which informal collegial support was foundational to designing for interdisciplinary teaching and learning was both inspiring and concerning. However, the sustainability of those informal networks in the long term without further resourcing and institutionalisation of the practices identified in this thesis is uncertain. Simply put, support for designing for interdisciplinary teaching and learning involves a significant reliance on networks that have not been institutionalised.

The importance of physical, material, and technological aspects of designing in addition to epistemic and social aspects of design work was identified. When design work is conceived of as knowledge work, the physical, material, and technological aspects of design work matter. As Chapter 8 suggests, using or creating specific design spaces for designing interdisciplinary teaching and learning can enable diverse ways of thinking, collaborating, and combining in practice, which can be helpful for managing the complexity of design work. The use of analytical frameworks such as the ACAD framework can help to make the epistemic, social, and physical considerations of designing explicit which can help course leaders to be strategic in how they design.

The outcomes in this thesis also show that when design happens is not limited to the development or redesign of courses. Educational design in higher education has been described as extending beyond course creation to include redesign activities, which accounts for a major part of design work (Bennett et al., 2018). As noted in the *Characterised by*

ongoing learning section (Section 9.2), design was inclusive of not only redesign activities but also developing and sustaining interdisciplinary understanding and expertise, networks of support, processes of designing, spaces for design work, and ways of navigating the institutional environment. Interdisciplinary teaching and learning involved design activities that took place in advance of, during, and following teaching and learning activity. Supporting design for interdisciplinary teaching and learning can benefit from this widened scope of what designing for interdisciplinary teaching and learning involves.

Overall, this thesis has shown that the scope of designing for interdisciplinary teaching and learning is broad. It is characterised by collaboration and a reliance on informal collegial networks. The physical aspects of design work are important, and it is essential to have an expansive conception of *when* design happens.

Designing approaches for interdisciplinary teaching and learning

It has been argued that interdisciplinary teaching and learning discourse is focused too much on the development of students' skills, it can neglect the role of knowledge (Boon & Van Baalen, 2019). It has been argued that there is a need to bring knowledge back into interdisciplinary education to address the absence of attention given to the complexities of students' knowledge creation in interdisciplinary teaching and learning (Millar, 2016). The outcomes in this thesis show the significant role that knowledge plays in interdisciplinary teaching and learning, and in designing for interdisciplinary teaching and learning.

Interdisciplinary learning can be understood as both a feature of the teams (composition) and of the problems they work on (ways of working with knowledge) in students' interdisciplinary teamwork (Arthars et al., 2024; Jensen et al., 2019). When interdisciplinary learning is framed in relation to the composition of student teams and not in relation to ways of working with different epistemic practices in interdisciplinary knowledge work, the

mechanics of how knowledge work is accomplished may be obscured. There is therefore a need to be more explicit about what is meant when course leaders describe knowledge creation. How interdisciplinary learning is conceptualized can have significant impact on how course leaders design for interdisciplinary teaching and learning.

Further, this thesis shows that different approaches can help students develop different capabilities, preparing them to different extents for framing and addressing complex or wicked problems. Working with addressing complex or wicked problems in the world involves simultaneously framing and addressing them in light of different candidate tools, methods, theories, and epistemic practices (Goodyear & Markauskaite, 2019). How a problem is framed, therefore, impacts how it is addressed (Rittel & Webber, 1971). Developing students' autonomy may help them to create knowledge, but it may not prepare them with the agency to work effectively in interdisciplinary teams, nor prepare them with the epistemic agency to work with different disciplinary ways of creating knowledge to generate viable solutions to complex or wicked problems. Interdisciplinary knowledge work involves autonomy, agency, *and* epistemic agency. This is an important distinction to make when designing for interdisciplinary teaching and learning that aims to prepare students to frame and address wicked problems.

Developing design expertise for interdisciplinary teaching and learning

Teachers in higher education may be given significant autonomy in how and what they design (Bennett et al., 2017). However, they may not have developed the requisite capabilities to effectively design for interdisciplinary teaching and learning. The outcomes in this thesis show that designing for interdisciplinary teaching and learning involves the development of skills but is more characteristic of what Pennington (2008) refers to as a 'learning problem'; it is highly dynamic work that addresses novel challenges. It is characterised by course leaders' ongoing learning. Conceiving of designing for

interdisciplinary teaching and learning as knowledge work may help course leaders and university leadership understand the unique characteristics and responsibilities associated with designing for interdisciplinary teaching and learning.

Furthermore, the concepts of plurality, heterogeneity, and situatedness were ever-present throughout the thesis. However, simply noting that practices vary gives little support to those who are tasked with designing for interdisciplinary teaching and learning. This thesis identifies that there needs to be support for the development of design know-how, and also for course leaders' conceptual development regarding the diversity of understandings, purposes, and practices of interdisciplinary teaching and learning. This thesis raises awareness of the variation in the understandings and conceptions of course leaders. However, conceptual change is not achieved through awareness alone.

Additionally, this thesis identifies a need to document, research, and share knowledge about design that can help to sustain and develop course leaders' expertise. Designing for interdisciplinary teaching and learning should include a greater focus on researching design practices to generate useful design knowledge for course leaders, and for university leadership to inform their decision-making regarding interdisciplinary initiatives and supporting interdisciplinary educational practices.

Developing an institutional interdisciplinary design capacity

This thesis emphasises the need for people involved in interdisciplinary education to be explicit about their understandings, conceptions, and practices when designing, to avoid inadvertently homogenising or over-simplifying interdisciplinarity and its practices. This can help to enable mutual acknowledgement that can ground collaboration and communication.

Knowledge about how to design is rarely documented, articulated, or shared (McKenney et al., 2015), so the need to be explicit about understandings, aims, approaches,

processes, conceptions, and challenges is not specific to interdisciplinary teaching and learning. Due to the complexity of designing for interdisciplinary teaching and learning, this becomes imperative. Being explicit about understandings, conceptions, approaches, processes, and ways of navigating the institutional environment can be a first step towards making these practices visible and therefore acknowledged. This can help address risks to the sustainability of interdisciplinary education due to a lack of transparency and, more importantly, a lack of empirical research on its practices.

Furthermore, it has been argued that universities must balance innovation with quality assurance (Ellis & Goodyear, 2019). Interdisciplinary teaching and learning practices shape institutional environments in moderate, yet important, ways. However, the outcomes question the emphasis commonly placed on pedagogical innovations as a means to drive change in universities. There is a need for research that generates design knowledge for interdisciplinary teaching and learning that can help to address the quality of design practices for interdisciplinary teaching and learning, thereby addressing concerns about the quality of interdisciplinary courses.

Methodological Contribution

In this thesis, the ACAD framework (Goodyear & Carvalho, 2018) and the ACAD wireframe (Goodyear et al., 2021) were used as heuristics to holistically investigate course leaders' experiences, ensuring consideration of the social, set, and epistemic aspects of course leaders' design experiences at different levels within an institutional environment. Additionally, by taking an analytical approach, ACAD provided structure to the investigation of the complexity and uncertainty of the phenomenon of designing for interdisciplinary teaching and learning. The usefulness of the ACAD framework and ACAD wireframe in this thesis presents a use case for how it can be used in future studies on interdisciplinary design

practices to support ecological approaches that extend beyond the investigation of pedagogical approaches when complexity and variation in practice are commonplace.

10.2 Limitations

This section discusses the limitations of the thesis concerning the selection of participants, the methods utilised, and the applicability of the outcomes.

To begin, the selection of participants is representative, not exhaustive. The thesis investigated the experiences of 23 course leaders of a potential 80 identified interdisciplinary courses offered by the university. A maximum variation strategy was used to generate the sample to ensure diversity of experiences to ensure exploration of course leaders' experiences that were associated with different faculties, years of experience, and course types.

There are further limitations associated with the methods used in this study. The thesis is based on data from semi-structured interviews. It investigated course leaders' experiences of designing for interdisciplinary teaching and learning, but did not directly investigate their design practices. Kane et al. (2002) argue that when research is focused only on what participants say about practice but not on practices themselves, there is a risk of the researcher telling 'half the story.' Further research is therefore needed that directly investigates course leaders' design practices.

Additionally, to mitigate the risks of using outcomes from the same dataset for five different analyses, subsets of data were identified in advance for each research question and were not used beyond their allocated area of investigation.

There are also limitations in relation to the applicability of the study's outcomes. The study was conducted at a comprehensive Australian university made up of different faculties and administrative structures, including interdisciplinary research centres. There was also wide variation in the types of interdisciplinary courses offered by the university. Sin (2010)

argues that phenomenographic outcomes are not intended to be generalised. However, due to the large, comprehensive nature of the university, the research setting may share commonalities with those at other universities. The study's outcomes therefore remain useful in that they expand awareness of the variation in how the phenomenon of designing for interdisciplinary teaching and learning is experienced at a large, comprehensive university, making them relevant to a wide audience.

Lastly, there are different ways of conducting phenomenographic research, and how phenomenographic research is conducted is constantly evolving (Åkerlind, 2024). Aspects of the approach taken in this thesis are novel, but I have attempted to stay true to the purposes, processes, and strategies for ensuring trustworthiness in phenomenographic research. The approach used enabled the study of significant variation across a university. Some flexibility was required.

10.3 Future Research

The five articles each present suggestions for future research. This section will summarise them and, in some cases, extend upon them in consideration of the synthesised findings.

Chapters 4–8 each suggested future studies. In Chapter 4, the need for further investigation into the influence of institutionally accepted understandings and students' understandings of interdisciplinarity was identified. In Chapter 5, investigation of university leaderships' conceptions of the purpose of interdisciplinary education was identified as an area for further research to complement the investigation of course leaders' conceptions of purpose. In Chapter 6, fine-grained research exploring course design artefacts in relation to approaches to interdisciplinary teaching and learning was proposed. In Chapter 7, future research suggestions included design praxeology (the study of design processes) and the role of spaces, materials, and technologies in design processes. Lastly, in Chapter 8, further

research on the informal communities of support for designing for interdisciplinary teaching and learning was identified as a means to understand how interdisciplinary course leaders learn in design activity, which can also inform decision-making regarding how to support interdisciplinary course leaders' professional development and support their practices.

Course leaders, in Chapter 7, also identified a desire to conduct research on their own design practices. So further research is needed to understand what may inhibit interdisciplinary course leaders from conducting research on their own design practices in order to generate useful design knowledge.

10.4 Concluding Remarks

The aim of investigating the variation in how course leaders experience designing for interdisciplinary teaching and learning is to generate knowledge that can be of use to people who are responsible for creating, adapting, and sustaining interdisciplinary courses in higher education. Bakker (2018) argues that “for knowledge to be actionable (what people find important and what works), it has to be relatively simple” (p. 47). However, there is nothing simple about designing for interdisciplinary teaching and learning. It bridges multiple fields of study and often involves teamwork that could include teachers, professional staff, stakeholders, and students from a mix of disciplines and knowledge cultures. Being explicit about what design practices for interdisciplinary teaching and learning entails is the alternative to simplicity. By logically mapping out variation and identifying the relationships between outcomes, this thesis can assist others in developing awareness of what is involved in, and the variation in ways of, designing for interdisciplinary teaching and learning.

A key insight that I gained through the process of designing, conducting, analysing, and translating the outcomes of this study is the need to avoid simplification of what is

entailed in designing for interdisciplinary teaching and learning. It requires awareness and a reflexive approach to avoid discussing ‘context’ without providing boundaries around what is meant, dichotomising disciplinarity and interdisciplinarity, conflating design aims with design approaches, oversimplifying what is entailed in knowledge creation, and conflating the aims of designing with the processes of designing. Throughout this thesis, I have argued against the temptation to collapse understandings, purposes, approaches, processes and practices into a simplified whole. Rather, each needs to be seen as having its place on a spectrum of ways of experiencing designing for interdisciplinary teaching and learning. This can help to address the tendency to oversimplify or align ways of designing for interdisciplinary teaching and learning, supporting instead the variation and construction of understandings, conceptions, approaches, processes, and practices that are suitable to local settings. It is not an easy task, but being explicit about designing for interdisciplinary teaching and learning can help to avoid oversimplification of its complexity.

To conclude, this thesis maps out the variance in interdisciplinary course leaders' experiences designing for interdisciplinary teaching and learning. This can be useful to universities to identify ways to build towards an institutional design capacity for designing for interdisciplinary teaching and learning. The outcomes in this thesis create a starting point for further research into interdisciplinary educational design practices that can support the sustainability and quality of interdisciplinary education. This can be beneficial to advancing both interdisciplinary and disciplinary education in universities and can in turn benefit student and their contribution to society.

References

- Åkerlind, G. S. (2005). Variation and commonality in phenomenographic research methods. *Higher Education Research and Development*, 24(4), 321–334.
<https://doi.org/10.1080/07294360500284672>
- Åkerlind, G. S. (2008). A phenomenographic approach to developing academics' understanding of the nature of teaching and learning. *Teaching in Higher Education*, 13(6), 633–644. <https://doi.org/10.1080/13562510802452350>
- Åkerlind, G. S. (2012). Variation and commonality in phenomenographic research methods. *Higher Education Research and Development*, 31(1), 115–127.
<https://doi.org/10.1080/07294360.2011.642845>
- Åkerlind, G. S. (2018). What future for phenomenographic research? On continuity and development in the phenomenography and variation theory research tradition. *Scandinavian Journal of Educational Research*, 62(6), 949–958.
<https://doi.org/10.1080/00313831.2017.1324899>
- Åkerlind, G. S. (2024). Common misunderstandings of phenomenographic research in higher education. *Higher Education Research and Development*, 43(1), 1–16.
<https://doi.org/10.1080/07294360.2023.2218804>
- Arthars, N., Markauskaite, L., & Goodyear, P. (2024). Constructing shared understanding of complex interdisciplinary problems: Epistemic games in interdisciplinary teamwork. *The Journal of the Learning Sciences*, 33(2), 405–442.
<https://doi.org/10.1080/10508406.2024.2341390>
- Ashby, I., & Exter, M. (2019). Designing for interdisciplinarity in higher education: Considerations for instructional designers. *TechTrends*, 63(2), 202–208.
<https://doi.org/10.1007/s11528-018-0352-z>
- Ashwin, P. (2020). Teaching Excellence: Principles for Developing Effective System-Wide Approaches. In *Changing Higher Education for a Changing World* (pp. 131–143). Bloomsbury Publishing. <https://doi.org/10.5040/9781350108448.0018>
- Ashwin, P., Blackie, M., Pitterson, N., & Smit, R. (2023). Undergraduate students' knowledge outcomes and how these relate to their educational experiences: a longitudinal study of chemistry in two countries. *Higher Education*, 86(5), 1065–1080. <https://doi.org/10.1007/s10734-022-00962-1>

- Bakker, A. (2018). *Design Research in Education: A Practical Guide for Early Career Researchers*. Taylor and Francis. <https://doi.org/10.4324/9780203701010>
- Barnard, A., McCosker, H., & Gerber, R. (1999). Phenomenography: A qualitative research approach for exploring understanding in health care. *Qualitative Health Research*, 9(2), 212–226. <https://doi.org/10.1177/104973299129121794>
- Barry, A., & Born, G. (Eds.). (2013). *Interdisciplinarity: Reconfigurations of the social and natural sciences*. Routledge. <https://doi.org/10.4324/9780203584279>
- Bearman, M., & Ajjawi, R. (2024). The guideline multiple: beyond the dilemma of either relationships or standards. *Medical Education*, 1–3. <https://doi.org/10.1111/medu.15419>
- Bennett, S., Agostinho, S., & Lockyer, L. (2017). The process of designing for learning: Understanding university teachers' design work. *Educational Technology Research and Development*, 65(1), 125–145. <https://doi.org/10.1007/s11423-016-9469-y>
- Bennett, S., Lockyer, L., & Agostinho, S. (2018). Towards sustainable technology-enhanced innovation in higher education: Advancing learning design by understanding and supporting teacher design practice. *British Journal of Educational Technology*, 49(6), 1014–1026. <https://doi.org/10.1111/bjet.12683>
- Birks, M., & Mills, J. (2010). *Grounded theory: A practical guide*. SAGE.
- Boon, M., & Van Baalen, S. (2019). Epistemology for interdisciplinary research – Shifting philosophical paradigms of science. *European Journal for Philosophy of Science*, 9(1), 16. <https://doi.org/10.1007/s13194-018-0242-4>
- Boon, M., van Baalen, S., & Groenier, M. (2019). Interdisciplinary expertise in medical practice: Challenges of using and producing knowledge in complex problem-solving. *Medical Teacher*, 41(6), 668–677. <https://doi.org/10.1080/0142159X.2018.1544417>
- Bopardikar, A., Bernstein, D., Drayton, B., & McKenney, S. (2021). Designing educative curriculum materials in interdisciplinary teams: Designer processes and contributions. *Instructional Science*, 49(2), 249–286. <https://doi.org/10.1007/s11251-021-09538-5>
- Boradkar, P. (2017). Taming wickedness by interdisciplinary design. In R. Frodeman (Ed.), *The Oxford handbook of interdisciplinarity* (2nd ed., pp. 456–468). Oxford University Press. <https://doi.org/10.1093/oxfordhb/9780198733522.013.37>
- Bowden, J. A., & Green, P. (2005). *Doing developmental phenomenography*. RMIT University Press.
- Bowden, J. A., & Walsh, E. (2000). *Phenomenography*. RMIT University Press. <https://doi.org/10.3316/informit.0864590199>

- Brew, A., Boud, D., Lucas, L., & Crawford, K. (2022). Hampering teaching excellence? Academics making decisions in the face of contradictions. *Studies in Higher Education*, 47(4), 941–952. <https://doi.org/10.1080/03075079.2020.1828327>
- Cai, Y., & Lönnqvist, A. (2022). Overcoming the barriers to establishing interdisciplinary degree programmes: The perspective of managing organisational innovation. *Higher Education Policy*, 35(4), 946–968. <https://doi.org/10.1057/s41307-021-00242-0>
- Carvalho, L., & Goodyear, P. (2018). Design, learning networks and service innovation. *Design Studies*, 55, 27–53. <https://doi.org/10.1016/j.destud.2017.09.003>
- Carvalho, L., & Yeoman, P. (2021). Performativity of materials in learning: The learning-whole in action. *Journal of New Approaches in Educational Research*, 10(1), 28–42. <https://doi.org/10.7821/NAER.2021.1.627>
- Charmaz, K. (2001). Qualitative interviewing and grounded theory analysis. In J.D. Gubrium & J. A. Holstein (Eds.), *The handbook of interview research: Context and method* (pp. 675–94). Sage.
- Christensen, I.-M. F., & Markauskaite, L. (2025). Creating reusable design knowledge in interdisciplinary education: Current methodological practices and issues. In I.-M. F. Christensen, L. Markauskaite, N. B. Dohn, D. Ripley, & R. Hachmann (Eds.), *Creating design knowledge in educational innovation: Theory, methods, and practice* (pp. 96–109). Routledge. <https://doi.org/10.4324/9781003391432-12>
- Connell, R. (2019). *The good university: What universities actually do and why it's time for radical change*. Zed Books. <https://doi.org/10.1111/ajph.12605>
- Cremers, P. H. M., Wals, A. E. J., Wesselink, R., & Mulder, M. (2017). Utilization of design principles for hybrid learning configurations by interprofessional design teams. *Instructional Science*, 45(2), 289–309. <https://doi.org/10.1007/s11251-016-9398-5>
- Cunningham, C. M., & Kelly, G. J. (2017). Epistemic practices of engineering for education. *Science Education*, 101(3), 486–505. <https://doi.org/10.1002/sce.21271>
- Damsa, Kirschner, Andriessen, Erkens, & Sins. (2010). Shared epistemic agency: An empirical study of an emergent construct. *Journal of the Learning Sciences*, 19(2), 143–186. <https://doi.org/10.1080/10508401003708381>
- de Greef, L., Post, G., Vink, C., & Wenting, L. (2017). *Designing interdisciplinary education: A practical handbook for university teachers*. Amsterdam University Press. <https://doi.org/10.1515/9789048535552>

- DeZure, D. (2017). Interdisciplinary pedagogies in higher education. In R. Frodeman (Ed.), *The Oxford handbook of interdisciplinarity* (2nd ed., pp.558–572). Oxford University Press. <https://doi.org/10.1093/oxfordhb/9780198733522.013.45>
- Ding, D., Nguyen, B., Gebel, K., Bauman, A., & Bero, L. (2020). Duplicate and salami publication: A prevalence study of journal policies. *International Journal of Epidemiology*, 49 (1), 281–288.
- Ellis, R. A., & Goodyear, P. (2019). *The education ecology of universities: Integrating learning, strategy and the academy*. Routledge. <https://doi.org/10.4324/9781351135863>
- Fenwick, T. J., Edwards, R., & Sawchuk, P. H. (2011). *Emerging approaches to educational research: Tracing the sociomaterial*. Routledge. <https://doi.org/10.4324/9780203817582>
- Friesen, S., Clark, D. B., Kim, B., & Jacobsen, M. (2023). Continuing the design discourse in the learning sciences. In *The learning sciences in conversation* (pp. 135–142). Routledge. <https://doi.org/10.4324/9781003089728-15>
- Goodyear, P. (2015). Teaching as design. *HERDSA Review of Higher Education*, 2, 27–50.
- Goodyear, P. (2018). Design research. *Health Education in Practice*, 1(1), 7–17.
- 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>
- Goodyear, P., & Ellis, R. A. (2020). Ecological thinking about education strategy in universities. In R. Barnett & N. Jackson (Eds.), *Ecologies for learning and practice: Emerging ideas, sightings and possibilities*. Routledge. <https://doi.org/10.4324/9781351020268-7>
- Goodyear, P., & Markauskaite, L. (2019). The impact on practice of wicked problems and unpredictable futures. In *Challenging Future Practice Possibilities*, (Vol. 1) Brill. <https://doi.org/10.1163/9789004400795>
- Goodyear, P., Markauskaite, L., Wrigley, C., Spence, N., Mosely, G., & Swist, T. (2023). Constructing design knowledge for postdigital science and education. In Postdigital Science and Education P. Jandrić, A. MacKenzie, & J. Knox (Eds.) *Constructing Postdigital Research*. Springer. https://doi.org/10.1007/978-3-031-35411-3_4
- Gournelos, T. (2019). *Doing academic research: A practical guide to research methods and analysis*. Routledge.

- Graff, H. J. (2016). The “problem” of Interdisciplinarity in theory, practice, and history. *Social Science History*, 40(4), 775–803. <https://doi.org/10.1017/ssh.2016.31>
- Haggis, T. (2003). Constructing Images of Ourselves? A Critical Investigation into ‘Approaches to Learning’ Research in Higher Education. *British Educational Research Journal*, 29(1), 89–104. <https://doi.org/10.1080/0141192032000057401>
- Han, F., & Ellis, R. A. (2019). Using phenomenography to tackle key challenges in science education. *Frontiers in Psychology*, 10, 1414. <https://doi.org/10.3389/fpsyg.2019.01414>
- Holley, K. A., & Szostak, R. (2022). *Interdisciplinary education and research in North America*. In *Institutionalizing Interdisciplinarity and transdisciplinarity* (Vol. 1, pp. 72–86). Routledge. <https://doi.org/10.4324/9781003129424-7>
- Hubbs, G., O’Rourke, M., & Orzack, S. H. (2021). *The toolbox dialogue initiative: The power of cross-disciplinary practice*. CRC Press.
- Kane, R., Sandretto, S., & Heath, C. (2002). Telling half the story: A critical review of research on the teaching beliefs and practices of university academics. *Review of Educational Research*, 72(2), 177–228. <https://doi.org/10.3102/00346543072002177>
- Kawa, N. C., Arceño, M. A., Goeckner, R., Hunter, C. E., Rhue, S. J., Scaggs, S. A., Biwer, M. E., Downey, S. S., Field, J. S., Gremillion, K., McCorriston, J., Willow, A., Newton, E., & Moritz, M. (2021). Training wicked scientists for a world of wicked problems. *Humanities & Social Sciences Communications*, 8(1), 1–11. <https://doi.org/10.1057/s41599-021-00871-1>
- Klein, J. T. (2005). *Humanities, culture, and interdisciplinarity: The changing American academy*. State University of New York Press. <https://doi.org/10.1353/book4993>
- Klein, J. T. (2010). *Creating campus cultures. A model for strength and sustainability*. Jossey-Bass and Association of American Colleges and Universities.
- Knorr-Cetina, K. (2001). Objectual practice. In T. R. Schatzki, K. Knorr Cetina, & E. von Savigny (Eds.), *The practice turn in contemporary theory* (pp. 184–197). Routledge. <https://doi.org/10.4324/9780203977453>
- Knorr-Cetina, K. (1999). *Epistemic cultures: How the sciences make knowledge*. Harvard University Press. <https://doi.org/10.4159/9780674039681>
- Lansiquot, R. D. (2020). *Interdisciplinary team teaching: A collaborative study of high-impact practices*. Springer International Publishing. <https://doi.org/10.1007/978-3-030-56302-8>

- Laurillard, D. (2012). *Teaching as a design science: Building pedagogical patterns for learning and technology*. Routledge.
- Limbu, L., & Markauskaite, L. (2015). How do learners experience joint writing: University students' conceptions of online collaborative writing tasks and environments. *Computers and Education*, 82, 393–408.
<https://doi.org/10.1016/j.compedu.2014.11.024>
- Lindvig, K. (2023). Loud and soft voices of interdisciplinarity in higher education. In T. Øland, S. Sauzet, M. L. Ryberg, & K. Lindvig (Eds.), *Configurations of interdisciplinarity within education: Danish experiences in a global educational space* (pp. 94–118). Routledge. <https://doi.org/10.4324/9781003083245-5>
- Lindvig, K., Lyall, C., & Meagher, L. R. (2019). Creating interdisciplinary education within monodisciplinary structures: The art of managing interstitiality. *Studies in Higher Education*, 44(2), 347–360. <https://doi.org/10.1080/03075079.2017.1365358>
- Lindvig, K., & Hillersdal, L. (2019). Strategically unclear? Organising Interdisciplinarity in an Excellence Programme of Interdisciplinary Research in Denmark. *Minerva*, 57(1), 23–46. <https://doi.org/10.1007/s11024-018-9361-5>
- Lindvig, K., & Ulriksen, L. (2019). Different, difficult, and local: A review of interdisciplinary teaching activities. *The Review of Higher Education*, 43(2), 697–725. <https://doi.org/10.1353/rhe.2019.0115>
- Ludwig, D., & Ruphy, S. (2021). Scientific pluralism. In E. N. Zalta (Ed.), *Stanford Encyclopedia of Philosophy*. Stanford University. Retrieved from <https://plato.stanford.edu/archives/win2021/entries/scientific-pluralism>.
- Lyall, C., Meagher, L., Bandola, J., & Kettle, A. (2016). *Interdisciplinary provision in higher education: Current and future challenges*. Higher Education Academy. Retrieved from <https://documents.advance-he.ac.uk/download/file/document/4604>
- Manzini, E. (2015). *Design, when everybody designs: An introduction to design for social innovation*. The MIT Press.
- Markauskaite, L. (2020). Commentary: Learning for knowledge work practices in the wild. *Research Papers in Education*, 35(1), 105–115. <https://doi.org/10.1080/02671522.2019.1677762>
- Markauskaite, L., & Goodyear, P. (2017). *Epistemic fluency and professional education: Innovation, knowledgeable action and actionable knowledge*. Springer. <https://doi.org/10.1007/978-94-007-4369-4>

- Markauskaite, L., Schwarz, B., Damşa, C., & Muukkonen, H. (2024). Beyond disciplinary engagement: Researching the ecologies of interdisciplinary learning. *Journal of the Learning Sciences*, 33(2), 213–241. <https://doi.org/10.1080/10508406.2024.2354151>
- Markauskaite, L., & Wardak, D. (2015). Research students' conceptions of the role of information and communication technologies in educational technology research. *Australasian Journal of Educational Technology*, 31(4), 421–438. <https://doi.org/10.14742/ajet.1419>
- Marton, F. (1986). Phenomenography – A research approach to investigating different understandings of reality. *Journal of Thought*, 21, 28–49.
- Marton, F., & Booth, S. (1997). *Learning and awareness*. Lawrence Erlbaum.
- Marton, F., & Booth, S. (2013). *Learning and awareness*. Taylor & Francis. <https://doi.org/10.4324/9780203053690>
- Marton, F., & Säljö, R. (1976). On qualitative differences in learning. 1- outcome and process. *British Journal of Educational Psychology*, 46(1), 4–11. <https://doi.org/10.1111/j.2044-8279.1976.tb02980.x>
- 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>
- Menken, S., & Keestra, M. (2016). *An introduction to interdisciplinary research: Theory and practice* (Vol. 2). Amsterdam University Press.
- Millar, V. (2016). Interdisciplinary curriculum reform in the changing university. *Teaching in Higher Education*, 21(4), 471–483. <https://doi.org/10.1080/13562517.2016.1155549>
- Nersessian, N. J. (2019). Interdisciplinarity in action: Cognitive ethnography of bioengineering sciences research laboratories. *Perspectives on Science*, 27(4), 553–581. https://doi.org/10.1162/posc_a_00316
- Neuman, W. L. (2014). *Social research methods: Qualitative and quantitative approaches* (Seventh edition, Pearson new international edition.). Pearson.
- Nikitina, S. (2005). Pathways of interdisciplinary cognition. *Cognition and Instruction*, 23(3), 389–425. https://doi.org/10.1207/s1532690xci2303_3
- Nowotny, H. (2019). Prologue: The messiness of real-world solutions. In *Investigating interdisciplinary collaboration* (pp. 1–4). Rutgers University Press. <https://doi.org/10.36019/9780813585918-002>

- Øland, T., Sauzet, S., Ryberg, M. L., & Lindvig, K. (2022). *Configurations of Interdisciplinarity within education: Danish experiences in a global educational space* (Vol. 1). Routledge. <https://doi.org/10.4324/9781003083245>
- Oliver, B., & Jorre de St Jorre, T. (2018). Graduate attributes for 2020 and beyond: Recommendations for Australian higher education providers. *Higher Education Research and Development*, 37(4), 821–836. <https://doi.org/10.1080/07294360.2018.1446415>
- Orgill, M. (2012). Phenomenography. In N. M. Seel (Ed.), *Encyclopedia of the sciences of learning*. Springer. https://doi.org/10.1007/978-1-4419-1428-6_271
- Paavola, S., & Hakkarainen, K. (2005). The knowledge creation metaphor—An emergent epistemological approach to learning. *Science & Education*, 14(6), 535–557. <https://doi.org/10.1007/s11191-004-5157-0>
- Paavola, S., & Hakkarainen, K. (2021). Trialogical learning and object-oriented collaboration. In *International handbook of computer-supported collaborative learning* (pp. 241–259). Springer International Publishing. https://doi.org/10.1007/978-3-030-65291-3_13
- Pennington, D. D. (2008). Cross-disciplinary collaboration and learning. *Ecology and Society*, 13(2), 8–. <https://doi.org/10.5751/ES-02520-130208>
- Pongrácz, P., & Camerlink, I. (2022). Unethical ‘salami slicing’ versus appropriately dividing data into multiple publications. *Applied Animal Behaviour Science*, 250, 105611. <https://doi.org/10.1016/j.applanim.2022.105611>
- Prosser, M., & Trigwell, K. (1999). Relational perspectives on higher education teaching and learning in the sciences. *Studies in Science Education*, 33(1), 31–60. <https://doi.org/10.1080/03057269908560135>
- Repko, A. F., Szostak, R., & Phillips Buchberger, M. (2017). *Introduction to interdisciplinary studies* (2nd ed.). SAGE.
- Rittel, H. W. J., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy Sciences*, 4(2), 155–169. <https://doi.org/10.1007/BF01405730>
- Säljö, R. (1988). Learning in educational settings: Methods of enquiry. In P. Ramsden (Ed.), *Improving Learning: New Perspectives* (pp. 32–48). Kogan. <https://doi.org/10.3384/confero.2001-4562.231217>
- Säljö, R. (1997). Talk as data and practice – A critical look at phenomenographic inquiry and the appeal to experience. *Higher Education Research and Development*, 16(2), 173–190. <https://doi.org/10.1080/0729436970160205>

- Sandberg, J. (1997). Are phenomenographic results reliable? *Higher Education Research and Development*, 16(2), 203–212. <https://doi.org/10.1080/0729436970160207>
- Sills, D. L. (1986/2016). *A note on the origin of “interdisciplinary.”* Items, Retrieved May 3, 2016, from <https://items.ssrc.org/from-our-archives/a-note-on-the-origin-of-interdisciplinary/>.
- Sin, S. (2010). Considerations of quality in phenomenographic research. *International Journal of Qualitative Methods*, 9(4), 305–319. <https://doi.org/10.1177/160940691000900401>
- Small, L., McPhail, R., & Shaw, A. (2022). Graduate employability: The higher education landscape in Australia. *Higher Education Research and Development*, 41(3), 919–933. <https://doi.org/10.1080/07294360.2021.1877623>
- Stentoft, D. (2019). Three challenges for new students facing problem-based and interdisciplinary learning. In *Interdisciplinarity and problem-based learning in higher education* (pp. 49–60). Springer. https://doi.org/10.1007/978-3-030-18842-9_5
- Trigwell, K. (2000). A phenomenographic interview on phenomenography. In J. A. Bowden & E. Walsh (Eds.), *Phenomenography* (pp. 43–57). RMIT University Press.
- Trigwell, K. (2006). Phenomenography: An approach to research into geography education. *Journal of Geography in Higher Education*, 30(2), 367–372. <https://doi.org/10.1080/03098260600717489>
- Trowler, P., Ashwin, P. and Saunders, M. (2014). *The Role of HEFCE in Teaching and Learning Enhancement: A Review of Evaluative Evidence*, York: Higher Education Academy.
- van Goch. (2024). Interdisciplinary practices in higher education: An introduction. In *Interdisciplinary practices in higher education: Teaching, learning and collaborating across borders*. Routledge.
- Vienni Baptista, B., Fletcher, I., Maryl, M., Wciślik, P., Buchner, A., Lyall, C., Spaapen, J., & Pohl, C. (2020). Final report on understandings of interdisciplinary and transdisciplinary research and factors of success and failure. *Zenodo*. <https://doi.org/10.5281/zenodo.3824839>
- Vienni Baptista, B., Klein, J. T., & Streck, D. (2022). Conclusion: A comparative framework for institutionalizing inter- and trans-disciplinary research and teaching in higher education. In *Institutionalizing Interdisciplinarity and transdisciplinarity* (Vol. 1, pp. 232–248). Routledge. <https://doi.org/10.4324/9781003129424-19>

- Vienni-Baptista, B., van Goch, M., van Lambalgen, R., & Ellemose Lindvig, K. (Eds.). (2024). *Interdisciplinary practices in higher education: Teaching, learning and collaborating across borders*. Routledge. <https://doi.org/10.4324/9781003286004>
- Weingart, P., & Padberg, B. (2014). Interdisciplinarity again ... or Still? . . . or still? In *University experiments in Interdisciplinarity*, 7–10. Transcript-Verlag. <https://doi.org/10.14361/transcript.9783839426166.7>
- Whitchurch, C. (2013). *Reconstructing identities in higher education: the rise of Third space professionals*. Routledge. <https://doi.org/10.4324/9780203098301>

Appendices

Appendix A: Participant Information Statement



Building A35
Sydney School of Education and Social Work
The University of Sydney
NSW 2006 AUSTRALIA

ABN 15 211 513 464

Professor Lina Markauskaite
Professor Peter Goodyear
Professor Cara Wrigley

Telephone: +61 2 9036 5320
Email: lina.markauskaite@sydney.edu.au
Web: <http://www.sydney.edu.au/>

Developing interdisciplinary expertise in universities

PARTICIPANT INFORMATION STATEMENT

(1) What is this study about?

This research study investigates how institutions, teams and individuals develop the expertise to work across disciplinary boundaries. It is conducted within the Charles Perkins Centre and Sydney Nano Institute involving staff and students engaged in interdisciplinary research and education at various levels. The study also involves participants from other multidisciplinary research centres and interdisciplinary units and courses at The University of Sydney.

You have been invited to participate in it because you are involved in an interdisciplinary research project or teaching an interdisciplinary course that we would like to investigate in this research study.

This Participant Information Statement tells you about this study. Knowing what is involved will help you decide if you want to take part in it. Please read this sheet carefully and ask questions about anything that you don't understand or want to know more.

Participation in this research study is voluntary.

By giving your consent to take part in this study, you will be telling us that you:

- ✓ Understand what you have read.
- ✓ Agree to take part in the research study as outlined below.
- ✓ Agree to the use of your personal information as described.

You will be given a copy of this Participant Information Statement to keep.

(2) Who is running the study?

The study is being carried out by the following researchers from the University of Sydney:

- Lina Markauskaite, Professor of Learning Sciences, Sydney School of Education & Social Work

- Peter Goodyear, Professor of Education, Sydney School of Education and Social Work
- Cara Wrigley, Professor of Design Innovation, Sydney School of Architecture, Design and Planning
- Celina McEwen, Postdoctoral Research Associate, Sydney School of Education and Social Work
- Dwayne Ripley, PhD Candidate, Sydney School of Education and Social Work

This study is funded by the Australian Research Council (DP200100376, 2020-2024).

(3) What will the study involve for me?

We are inviting you to participate in the first phase of the project in which we are investigating and mapping how interdisciplinary research and teaching teams do their work.

Initially, we will ask you and your colleagues to allow us to observe team meetings in which you are involved as a part of your work. We will also collect copies of some materials that your team uses or produces during these meetings (e.g., drawings, notes, etc.). We may ask some clarifying questions and ask you to share with us some additional materials (e.g., reports, presentation slides, agendas and minutes of meetings), after these observations. They are to help us understand your work better.

If you and other members of your team are interested in being involved in this study beyond this first phase, we will discuss possibilities with your team. These may include further observation of work activities, interviews of up to 60 minutes and visits of work spaces. You do not need to commit any further time at this point.

(4) How much of my time will the study take?

These observations will not require much of your time as we want to observe work that you would be doing anyway. Questions that we may ask after these observations will be short (5-10 minutes).

If you and other members of your team are interested in being more involved in this project, we anticipate that within the first year, each team member will participate in up to 2 individual interviews (2 hours per person, in total) and allow us to observe some other work activities (e.g., meetings, seminars, online teamwork spaces). These observations will not require additional time from you.

Overall, this research study will last four years, and we expect that levels of participation by individual researchers and research teams will vary greatly. If you and your team agree to participate further, you will be able to choose the level of involvement that suits you.

(5) Who can take part in the study?

Participants in this study are staff and students of The University of Sydney involved in interdisciplinary research projects and/or education. The study also includes external partners who collaborate on these projects (e.g., professionals from industry, researchers from other universities).

(6) Do I have to be in the study? Can I withdraw from the study once I've started?

Being in this study is completely voluntary, and you do not have to take part. Your decision will not affect your current or future relationship with the researchers or anyone else at The

University of Sydney.

If you decide to take part in the study and then change your mind later, you are free to stop participating at any time. We will not collect any more information from you.

You are free to stop the interview or observation at any time. If you do so, you can request the recording to be erased and the information you have provided not be included in the study results. You may also refuse to answer any questions that you do not wish to answer during the interview or request us to exclude from our research reports specific comments you made (e.g., confidential research information) during observations.

If you decide to withdraw from the study after data have been collected, you can do this in writing by emailing the Chief Investigator of this study, Lina Markauskaite (lina.markauskaite@sydney.edu.au). However, if your data have been already analysed, we may not be able to withdraw it from our findings.

(7) Are there any risks or costs associated with being in the study?

Aside from giving up your time and re-identification of your identity by people who know you well, we do not expect that there will be any costs or risks associated with taking part in this study. To mitigate any potential risks, we will provide you with several opportunities to withdraw from the study any part of your data until they are analysed. We will also take a number of protective measures described in point 9 below.

(8) Are there any benefits associated with being in the study?

We cannot guarantee that you will receive any direct benefits from being in the study. However, we expect that findings from this study will help improve interdisciplinary teamwork and teaching. In the later stages of this project, we will be working with interdisciplinary research and teaching teams, helping them transform our findings into practical tools and strategies for interdisciplinary work. All our study participants will be invited to join this work.

(9) What will happen to information about me that is collected during the study?

By providing your consent, you agree to us collecting personal information about you and your work for the purposes of this and future research studies about interdisciplinarity. Your information will only be used for the purposes outlined in this Participant Information Statement unless you consent otherwise.

With your permission, this information will be collected using one or more of the following methods: copies of documents (e.g., reports, presentation slides, notes, and agendas and minutes of meetings), audio- or video- recorded interviews, audio- or video-recorded observations of your work, researchers' notes and photographs capturing specific objects and episodes from your work.

In some circumstances, we may make video- and audio-recordings of you and other people working with you. We will only do this in circumstances where all the participants have given us permission to do so in advance.

Because of the historical value of this study, your de-identified information will be kept permanently in secure storage managed by The University of Sydney. Your information will be stored securely, and your identity/information will only be disclosed with your permission, except if required by law.

You will be able to access your personal information collected by us by emailing a written request to the Chief Investigator of this study Lina Markauskaite (lina.markauskaite@sydney.edu.au).

The results of this study will be published, but these publications will not contain any identifiable information about you unless you consent to be identified in the consent form. Information related to your work that you identify as confidential will not be included in any of the study's reports or presentations in any form that may reveal this information.

Extracts from audio- and video-recorded data and other collected materials (e.g., images from the video, photos of notes) may be used in the study's research reports, publications, and presentations. Unless you consent to being identified in the consent form, your anonymity will be protected by blurring your face and removing other identifying information. However, due to the qualitative nature of data, there is a chance that some people who know you and your work may be able to re-identify you. If we have concerns that some results, if they are re-identified, may negatively affect you, we will not publish them.

(10) Can I tell other people about the study?

Yes, you are welcome to tell other people about the study.

(11) What if I would like further information about the study?

When you have read this information, an investigator from the research team will be available to discuss it with you further and answer any questions you may have. If you would like to know more at any stage during the study, please feel free to contact the Chief Investigator Lina Markauskaite (lina.markauskaite@sydney.edu.au).

(12) Will I be told the results of the study?

You have a right to receive information about the overall results of this study. You can tell us that you wish to receive feedback by providing your email address on the consent form. This information will be in the form of a summary of key findings. You will receive this information after the study is finished.

(13) What if I have a complaint or any concerns about the study?

In Australia, research involving humans is reviewed by an independent group of people called a Human Research Ethics Committee (HREC). The ethical aspects of this study have been approved by the HREC of the University of Sydney [project number 2020/668]. As part of this process, we have agreed to carry out the study according to the *National Statement on Ethical Conduct in Human Research (2007)*. This statement has been developed to protect people who agree to take part in research studies.

If you are concerned about the way this study is being conducted or you wish to make a complaint to someone independent from the study, please contact the university using the details outlined below. Please quote the study title and protocol number [project number 2020/668].

The Manager, Ethics Administration, The University of Sydney:
Telephone: +61 2 8627 8176

Email: human.ethics@sydney.edu.au
Fax: +61 2 8627 8177 (Facsimile)

This information sheet is for you to keep

Appendix B. Participant Consent Form



ABN 15 211 513 464

Professor Lina Markauskaite
Professor Peter Goodyear
Professor Cara Wrigley

Building A35
Sydney School of Education and Social Work
The University of Sydney
NSW 2006 AUSTRALIA

Telephone: +61 2 9036 5320
Email: lina.markauskaite@sydney.edu.au
Web: <http://www.sydney.edu.au/>

Developing interdisciplinary expertise in universities PARTICIPANT CONSENT FORM

I, [PRINT NAME], agree to take part in this research study.

In giving my consent, I state that:

- ✓ I understand the purpose of the study, what I will be asked to do, and any risks/benefits involved.
- ✓ I have read the Participant Information Statement and have been able to discuss my involvement in the study with the researchers if I wished to do so.
- ✓ The researchers have answered any questions that I had about the study, and I am happy with the answers.
- ✓ I understand that being in this study is completely voluntary, and I do not have to take part in it. My decision whether to be in the study will not affect my relationship with the researchers or anyone else at The University of Sydney now or in the future.
- ✓ I understand that I can withdraw from the study at any time.
- ✓ I understand that if I am participating in one or several interviews, I may stop my participation at any time if I do not wish to continue. If I do so, I can request the interview to be erased and the information provided by me excluded from the study. I also understand that I may refuse to answer any question I don't wish to answer.
- ✓ I understand that if I am participating in observations, I may stop my participation at any time. If I do so, I can request the recording to be erased and the information provided by me excluded from the study. I also understand that I can request the investigators to exclude some specific comments from research reports (e.g., confidential research information).
- ✓ I understand that copies of materials associated with my participation in the study (e.g., examples of papers, proposals, drafts, drawings, and notes produced during observations) may be collected by the researchers for data analysis. I also understand that I can refuse to give my permission to collect and analyse any of the materials.
- ✓ I understand that personal information about me that is collected over the course of this project will be stored securely and will only be used for purposes that I have agreed to. I understand that information about me will only be told to others with my permission, except if required by law.

- ✓ I understand that my information will be kept permanently in secure storage managed by The University of Sydney.
- ✓ I understand that the results of this study may be published. These publications will not contain my name or any identifiable information about me unless I consent to being identified by ticking the “Yes” checkbox below.
- ✓ I understand that extracts from video- and audio-recordings and collected materials (e.g., images from a video, photos of notes) may be used in research reports and presentations. In these instances, my anonymity will be protected by blurring my face and removing other identifying information, unless I consent to being identified.
- ✓ I understand that while my anonymity will be protected by de-identifying all my personal information in publications and presentations, due to the qualitative nature of data, there is a chance that some people who know me and my work may be able to re-identify me.
- ✓ I understand that information related to my research that I will identify as confidential will not be revealed in the study’s reports.

I want to be identified in research reports and publications:

☐ Yes, I am happy to be identified.

☐ No, keep my identity anonymous.

I consent to:

- | | | | | |
|---|-----|--------------------------|----|--------------------------|
| • Copies of materials that I produce during observations or give to the investigators being collected | YES | ☐ | NO | ☐ |
| • Being audio-recorded | YES | ☐ | NO | ☐ |
| • Being video-recorded | YES | ☐ | NO | ☐ |
| • Being photographed | YES | ☐ | NO | ☐ |
| • Deidentified extracts from visual data be included in publications and presentations | YES | ☐ | NO | ☐ |

I would like to receive updates about the overall results of this study:

YES ☐ NO ☐

If you answered ‘YES’, please provide your email address:

_____@_____

.....
Signature

.....
PRINT name

.....
Date

Appendix C. Interview Schedule

An indicative pool of questions

Notes for the interviewer:

1. Prepare for interviews by reviewing professional Profile on public websites (e.g. University's profile page, Google Scholar, Personal-professional website(s), LinkedIn).
2. Archive copies of the main pages by saving them as PDF documents.
3. Create a summary of the Profile using Profile Form.
4. Adapt the interview schedule below as necessary.
5. Ask interviewee if they have any questions about the project.
6. Ask interviewees if they consent to their information being used as part this research project as outlined in the PIS.
7. Remind participants to tell interviewer to exclude particular statements if they are confidential.
8. Begin by reminding them of the focus of the study, which is to explore their conceptions of interdisciplinarity, and their design experiences for ID teaching and learning.

1. Could you please briefly tell me about your career trajectory?

- a. What is your (disciplinary) background and your degrees?
- b. When did you graduate from your last degree? In which areas/discipline?
- c. How long have you been in academia? (research & teaching)
- d. What is your current role and what are your responsibilities?

2. Can you tell me about your involvement in ID education?

- a. How long have you been involved in interdisciplinary education?
- b. How did you get involved in ID education?
- c. Why do you engage in ID education?
- d. What have been your ID teaching roles? Can you provide 2-3 examples of recent experiences?

3. What does interdisciplinarity mean to you?

- a. What purpose does interdisciplinarity serve in the field in which you work and teach? Can you provide some examples of this?
- b. Are there any other purposes or roles that ID plays in the field in which you work and teach? Can you provide some examples of this?

4. How do you view the purpose of interdisciplinarity in teaching and learning in higher education?

- a. How do you view the purpose of ID teaching and learning in HE?
- b. In your experience, what do students learn from ID teaching and learning? Can you provide any examples?
- c. How is ID education preparing them for work and life? Can you provide any examples?
- d. What benefits if any does ID teaching and learning provide society?

5. Can you tell me about your background in creating units/courses in HE?

- a. In general, how many units/courses have you created?
- b. How did you learn to create units/courses?
- c. What are some resources that you draw upon when creating units/courses?
- d. What units/courses have you recently created/designed?

- e. What is the most complex unit/course you've had to create? Please explain and tell me how and why the unit/course creation was complex?
- 6. What have been your experiences (if any) in co-creating an ID unit/course? Can you tell me about one experience that stands out to you? If not, why have you not co-created any units?**
 - a. Who was involved and how? (and their backgrounds)
 - b. What was the purpose of the unit/course? (What were you trying to achieve?)
 - c. What were you actually creating when you were co-creating/co-designing? (the object of design)
 - d. How was the unit/course interdisciplinary?
 - e. What was the student disciplinary composition, and what did students do? (project, groups)
 - f. How was the design process managed and organised? (technologies, roles, labour, meetings)
 - g. What were some of the insights you gained from the co-creation/co-design process?
 - h. How did the experience differ from design for disciplinary units?
- 7. Can you tell me about any other experience you have had in creating an ID unit/course?**
 - a. Who was involved and how? (and their backgrounds)
 - b. What was the purpose of the unit/course? (What were you trying to achieve?)
 - c. Can you walk me through how you created the unit/course?
 - d. What were you actually creating? (What was the object of your design)
 - e. How was the unit/course interdisciplinary?
 - f. What was the student disciplinary composition, and what did students do? (project, groups)
 - g. How was the design process managed and organised? (technologies, roles, labour, meetings)
 - h. What did you need to learn to design effectively for an ID unit/course?
 - i. How did the experience differ from design for disciplinary units?
- 8. Can you tell me about 2–3 of the biggest challenges you faced in creating ID units/courses?**
 - a. What type of challenges were they? (physical, material, social)
 - b. At what level were the challenges situated? (personal, local, organisational, or global?)
 - c. How did you overcome the challenges?
 - d. What did you learn from the experience?
- 9. Can you provide me with 2–3 examples of things that enabled you to create ID units/courses?**
 - a. What type of enablers were they? (physical, material, social)
 - b. At what level were the enablers situated? (personal, local, organisational, or global?)
 - c. How did they help you to design?
 - d. What did you learn from the experience?
- 10. Are there any further thoughts you would like to share on your ID design experiences, or any other things you would like to note?**

Appendix D. Human Ethics Modifications

Figure D1. Ethics approval email to add Dwayne Ripley to the research project

Dwayne Ripley

From: Human Ethics <human.ethics@sydney.edu.au>
Sent: Friday, 11 December 2020 9:49 AM
To: Lina Markauskaite; Peter Goodyear; Celina McEwen; Cara Wrigley; Dwayne Ripley
Subject: [2020/668] Human Ethics: Change in personnel outcome

Dear Dr Markauskaite

Project Title: Developing interdisciplinary expertise in universities
Project number: 2020/668

Change in Personnel outcome

Thank you for submitting a change in personnel form for the above project. Your request has been processed and the change/s approved.

The current approved researchers are as follows:

Markauskaite Lina; Goodyear Peter; McEwen Celina; Wrigley Cara; Ripley Dwayne;

Please contact us if you have any queries or if there is an error in the above list.

Regards,
The Ethics Office

Research Integrity and Ethics Administration | Research Portfolio
THE UNIVERSITY OF SYDNEY
Level 3, Administration Building (F23) | The University of Sydney | NSW | 2006
T +61 2 9036 9161 | E human.ethics@sydney.edu.au | W <http://sydney.edu.au/ethics>

Figure D2. Ethics approval email to add units of study to the research project

Dwayne Ripley

From: Human Ethics <human.ethics@sydney.edu.au>
Sent: Thursday, 21 October 2021 12:03 PM
To: Lina Markauskaite; Leela Cejnar; Amanda Jane Bellaby; Peter Goodyear; Celina McEwen; Dwayne Ripley; Natalie Spence; Sujeewa Tennekoon; Alicia Josefina Vallero; g.mosely; Karla Straker; c.wrigley
Subject: [2020/668] Human Ethics: Modification outcome
Attachments: HEMod_CatA_2020-668ii.pdf

Dear Dr Markauskaite

Project Title: Developing interdisciplinary expertise in universities
Project number: 2020/668

Modification outcome

Your request to modify the above project was reviewed on **13 October 2021**.

Please find attached a letter regarding the outcome of your recent modification request.

The Committee approved this modification in the absence of ethical objections and on the basis of satisfactory scientific merit.

Questions?

If you have any queries you can contact us on the details below.

Regards,
The Ethics Office

Research Integrity and Ethics Administration | Research Portfolio
THE UNIVERSITY OF SYDNEY
Level 3, Administration Building (F23) | The University of Sydney | NSW | 2006
T +61 2 9036 9161 | E human.ethics@sydney.edu.au | W <http://sydney.edu.au/ethics>

Figure D3. Ethics approval attachment to add units of study to the research project



**Research Integrity & Ethics Administration
HUMAN RESEARCH ETHICS COMMITTEE**

Thursday, 21 October 2021

Dr Lina Markauskaite
School of Education and Social Work Research Operations; Faculty of Arts and Social Sciences
Email: lina.markauskaite@sydney.edu.au

Dear Lina,

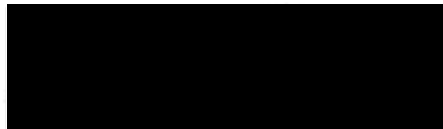
Your request to modify this project, which was submitted on 24 September 2021, has been considered.

This project has been approved to proceed with the proposed amendments (*inclusion of additional interdisciplinary and multi-disciplinary units of study at the University of Sydney that could be invited to participate in the study*).

Protocol Number: 2020/668
Protocol Title: Developing interdisciplinary expertise in universities
Annual Report Due: 19 November 2021

Please contact the ethics office should you require further information.

Sincerely,



Associate Professor Stephen Fuller
Chair
Modification Review Committee Chair (MRC 1)

The University of Sydney of Sydney HRECs are constituted and operate in accordance with the National Health and Medical Research Council's (NHMRC) [National Statement on Ethical Conduct in Human Research \(2018\)](#) and the NHMRC's [Australian Code for the Responsible Conduct of Research \(2018\)](#)