Chapter 6
The development of epistemic fluency: Learning to think for a living

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Thinking for a living
Most of the jobs taken up by university graduates involve knowledge-work: adding value to a product or service through the application of knowledge. This is true in the private sector but also in the professions and areas of public service, where there is a strengthening expectation that policies and practice will be informed by sound evidence. Tom Davenport characterises such work as 'thinking for a living' (Davenport, 2005). One might expect academia to be comfortable with the notion of knowledge work, but it would be fair to say that little of the literature on teaching and learning in higher education is underpinned by a confident or illuminating analysis of what this entails. It is a major problem when higher education is unable to provide an adequate theorisation of some of the key qualities demanded of its graduates (Barrie, 2006).

This chapter emerges from the following combination of concerns. First, we are interested in getting a firmer understanding of some of the key characteristics of knowledge work. Knowing how tasks are carried out by experienced knowledge workers is a prerequisite for helping students learn how to carry out such tasks. Secondly, we have been investigating 'learning through discussion', in higher education settings, with students who are involved in both face-to-face and online discussions. Discussion is taken-for-granted, valued and threatened in higher education. It is threatened by worsening staff:student ratios and by the reduction in the time students are willing or able to give to participation in on-campus activities. It is valued in images of the ideal forms of interaction and relationship in academia (Ashwin, 2005; Palfreyman, 2001). It is surprisingly under-researched and one does not often hear a clear articulation of its role when discussion-based activities are being slotted into a course plan. Part of our research focuses on how students make sense of learning through discussion; what they believe it is good for, how they approach discussion tasks, etc. Thirdly, we are interested in educational design. As researchers, and in our daily work, we want a richer understanding of how to design, or help our colleagues design, engaging productive learning tasks, supported by appropriate tools and learning resources. These three sets of concerns combine to connect educational design, learning through discussion and apprenticeship in knowledge work.

The diverse disciplinary contexts in which we have been working include the social and health sciences and engineering. A unifying feature is that, in each of these contexts, we have been collaborating with teachers who are trying to find good ways of combining online and face-to-face discussion activity within the courses they teach. We have found that the apparently new challenges involved in finding appropriate uses for computer technology shed light on broader and more enduring questions about learning activity and curriculum goals. It turns out that the different affordances of face-to-face and online discussion have implications for the connections between discussion and collaboration in knowledge-building. Neither is intrinsically superior to the other; they

can have complementary strengths. We pay particular attention to the way that online discussion creates a shared and persisting record of ideas and to the implications this has for the collaborative improvement of ideas.

Our chapter proceeds as follows. We start with an overview of the areas of academic practice that have been involved in our recent research, but make some bold claims about the general applicability of what we have to say. Then we survey some of the literature on which we have been drawing, offering a conceptualising of apprenticeship in knowledge work and a summary of some recent research on learning through discussion in higher education. In particular, we focus on evidence of conceptions of discussion that are compatible with our sense of what apprenticeship in knowledge work ought to entail. We find few signs of such conceptions. This segues into our own research. We summarise the methods and outcomes of some of our recent and ongoing empirical studies of learning through (face-to-face and online) discussion. Finally, we draw out some implications for practice.

The overall aim of our chapter is to demonstrate the need for a more firmly grounded account of the place of discussion in learning to 'think for a living'. In our view, collaboration in knowledge-building, as a curriculum goal and as a pedagogical strategy, needs teachers and students to be clear about the intention behind, and the form to be taken by, students' collaborative engagement in knowledge work. The ability to distinguish between different intentions and forms depends upon a more sophisticated set of ideas about knowledge work than we are finding in our interview data.

Areas of academic practice involved in our research
Our recent research has gathered data from a number of academic areas, including education, social work, sociology, political science, engineering, pharmacy and law. Studies have included both postgraduate and undergraduate students. A small subset of the data has come from courses in which we've been involved as teachers or advisers. For the most part, it represents experience from courses in which we have had no direct stake, run at Sydney and at other universities, including universities in the UK. Typically, the research has been done in close partnership with the teachers who direct the courses concerned. Part of the motivation has been to work with these teachers in order to come to a better understanding of their students' experiences, with a view to distilling specific ideas for improving their courses, as well as more general implications for better educational designs. All of the data comes from courses in which students spend some of their time engaged in online collaborative activity, ranging in kind from loosely structured discussion to tightly scripted group projects. None of it comes from courses in which teachers were experimenting with online activity for the first time, or courses where students' evaluations made it clear that there were serious problems with the course. Most of our work has involved relatively small samples – never more than 200 in our questionnaire studies, and 20-60 in each of our interview studies. Nevertheless, we think the implications are worth serious consideration by anyone who is interested in the education of knowledge workers or the role of learning through discussion.

Apprenticeship in knowledge work, learning through discussion and educational design

Apprenticeship in knowledge work

> 'In a complex, multicultural society such as ours, truth takes many forms. Different contexts and different subcultures support different ways of constructing knowledge, and different ways of understanding what it means to 'know' something' (Morrison & Collins, 1996, p. 108).

We have been drawing on the writings of a number of scholars whose work makes connections between educational practice and cognitive science in order to develop a conception of 'apprenticeship in knowledge work' that is both rich and precise. David Perkins, Stellan Ohlsson and Allan Collins have provided some useful ideas about the special qualities of knowledge work, rendered in terms of epistemic tasks (Perkins & Blythe, 1994; Ohlsson, 1995; Collins & Ferguson, 1993; Morrison & Collins, 1996). More recently, Carl Bereiter has drawn on Popper's 'Three Worlds' ontology as a way of distinguishing between learning and knowledge-building (Bereiter, 2002; Bereiter & Scardamalia, 2003). We find these writers helpful, because they take us *beyond* the mere acknowledgement that knowledge is socially constructed and that knowledge-claims are contestable, needing to be understood relative to the norms, values and practices of a culture (Barnett & Griffin, 1997; Berger & Luckmann, 1967; Latour & Woolgar, 1986). The fact that knowledge is relative does not make it simple or arbitrary.

Allan Collins provides some vocabulary for talking about key elements of knowledge work: *epistemic forms* and *epistemic games*. Epistemic forms are 'target structures that guide inquiry' (Morrison & Collins, 1996, p. 109). Epistemic games are 'sets of moves, constraints, and strategies that guide the construction of knowledge *around a particular epistemic form*' (*loc. cit.*, our emphasis). Taxonomic hierarchies, stage models, systems dynamic models and even simple lists can be examples of epistemic forms. Just as one cannot become a batsman merely by watching cricket, so one has to *play* epistemic games – ideally with people who are better at the game than you are.

Collins was thinking primarily of science education, in which epistemic forms and games mainly serve purposes of explanation and prediction. We believe the constructs are also useful in other areas of work. For example, in many areas of professional practice or corporate work, one can identify epistemic forms that are a combination of action-oriented knowledge (e.g., a plan, strategy, procedure or set of recommendations) plus a warrant or rationale (the evidence and argument justifying the action). Drawing on some of the courses we have studied in recent years, we could add examples such as a Use Case in software engineering, an ordered list of symptoms of schizophrenia, in psychology, or a legal opinion in law. The broader point is that the constructs of 'epistemic forms' and 'epistemic games' are useful tools for carrying out a cognitive anthropology of an epistemic culture. If we think of ways of formulating shared professional knowledge claims in an area like school teaching, for example, we can turn up epistemic forms such as a curriculum plan, or a grouping strategy, and its accompanying rationale. We can interpret the activities involved in producing such epistemic forms by focusing on those aspects which can be understood as moves in the corresponding epistemic game.

Epistemic fluency can then be defined as the ability to recognise and participate in a variety of epistemic games 'to identify and use different ways of knowing, to understand their different forms of expression and evaluation, and to take the perspective of others who are operating within a different epistemic framework' (Morrison & Collins, 1996, p. 109). We argue that students benefit from induction into more than one epistemic community (knowledge-building community), such that they can engage in what Lave and Wenger (1991) call 'legitimate peripheral participation' in the work of each community and can also come to recognise that different communities have different knowledge-building practices. Such communities may be academic or vocational in their primary orientation, and ideally students should have experience of communities in which both the creation and the application of knowledge have value and are well-understood.

An important element of this socio-cultural view of learning is that *participation* in authentic knowledge-creation activities, coupled with a growing sense of oneself as a legitimate and valued member of a knowledge-building community, are essential to the development of an effective knowledge-worker. Action and identity are key.

At this point, we need to introduce a distinction between 'weak' and 'strong' interpretations of knowledge-building. Both are of value, but only the strong version amounts to authentic participation in knowledge work. The 'weak' version sees participation in collaborative knowledge-building as (just) a means to the end of personal conceptual development. To distinguish this from knowledge-building in a 'strong' sense, we need to follow Carl Bereiter in drawing on Karl Popper's 'Three Worlds'. World 1 is the objective world of physically existing things external to me (you, others, rain, rocks and sheep). World 2 is my subjective/inner world (mental states, beliefs, feelings). World 3 is the objective world of 'conceptual artifacts': ideas, theories, etc. The weak version of knowledge building is concerned solely with effects in World 2. The strong version is primarily concerned with activity and effects in World 3, though there may be beneficial side-effects in World 2. Bereiter (2002, pp. 64-68) talks about knowledge-building as collaboration in the improvement of conceptual artifacts. Collins, through the notion of 'epistemic forms', shows how we might identify *kinds* of conceptual artifacts that turn out to be important in a particular epistemic community – knowledge structures that are key to the distinctive ways of thinking and acting in that community (cf. McCune & Hounsell, 2005). Legitimate peripheral participation in World 3 knowledge building is how one learns to be a knowledge worker. Students can be given opportunities to participate in a number of different ways, for example through various kinds of research or inquiry task (Brew, 2006). However, collaboration in knowledge-building must always give a central place to discussion, so we now turn to this important but surprisingly neglected area.

Learning through discussion
There has been remarkably little research on learning through discussion in higher education, despite the central place it has had in many disciplines. A notable exception is the recent work of Helen Askell-Williams and Michael Lawson, which reports on students' beliefs about learning though discussion using data from school as well as university students. They show that students hold a wide range of beliefs about the educational purposes of discussion but that these can be reduced to five categories: information acquisition, remembering, comparison, motivation and knowledge construction (Askell-Williams & Lawson, 2005). At first glance, the knowledge

construction category looks as if it would come close to what we have in mind for apprenticeship in knowledge work, but on further examination it turns out that all of the purposes subsumed by this heading are to do with personal conceptual development. Discussions 'open my eyes to new points of view', 'help me to clarify my own opinions', 'help me expand my thinking', 'help me formulate my own thoughts' (pp. 99-101). One sub-category of purpose is labeled 'discussions facilitate the co-construction of knowledge' (p. 101) but this is used to describe situations in which two people help each other come to understand something. This is valuable, but it's firmly in World 2 rather than World 3.

Paul Ashwin's phenomenographic study of Oxford University students' conceptions of the 'Oxford Tutorial' also gives us some insight into what students see as the purposes of learning through discussion, albeit in a rarefied context. Ashwin's analysis results in four qualitatively different conceptions of the tutorial, distinguished by different conceptions of the roles of the participants and of the nature of knowledge (Ashwin, 2005). Tutorials are seen as (i) 'the tutor explaining to the student what the student does not understand', (ii) 'the tutor showing the student how to see the subject in the way the tutor does', (iii) 'the tutor bringing things into relation to each other to help the student develop a new perspective in the wider context of the discipline' and (iv) 'the tutor and the student exchanging different points of view on the topic and both coming to a new understanding' (op. cit., p. 635). Of these, only (iv) comes close to Bereiter's notion of collaboratively improving conceptual artifacts, and the implied purpose is still personal understanding (World 2) rather than the creation of new knowledge (World 3).

Students' beliefs about how they can benefit from participation in discussions are important because they are a strong influence on what students actually do when we set them a task. Other areas of belief and intention are also important: notably, students' personal epistemologies, conceptions of learning and approaches to study (Biggs, 2003; Hofer, 2000; Marton & Säljö, 1997; Perry, 1970; Prosser & Trigwell, 1999). If a student believes that there is only one right answer to a question, and that the teacher's job is to know and share the truth, then they are unlikely to see much value in debating different perspectives on the question with their fellow students. Conversely, if a student sees all knowledge claims as contestable and values the debate that flows from sharing personal interpretations of events, then they are more likely to engage in discussion with peers, even in cases where that discussion has no clear end in sight. Neither of these conceptions has the epistemological sophistication needed to create a space for collaborative knowledge-building in our strong (World 3) sense.

Educational design, discussion and collaborative knowledge-building
The kinds of face-to-face discussion that we find embedded in traditional university educational practice vary in format but are remarkably consistent in outcome. By this we mean that there are several recognisable ways of organising roles and the process of face-to-face discussion (e.g., a buzz group, a seminar led by a student on the topic of a journal article, an Oxbridge tutorial) but that the outcome is usually the same. What is left, at the end of such a discussion, is a set of cognitive and emotional traces, subtly different for each participant, and vulnerable to change and loss with the passage of time. There may be sets of private notes, or marks on butcher's paper, but it is not common educational practice to conclude a discussion with the production of a shared artifact.

Online discussion is different. Online discussion *is* the production of shared artifacts – normally texts. While the sound waves generated in a face-to-face meeting disappear into the ether, online discussion proceeds through producing and reflecting on *persistent* discourse. The personal and educational corollaries of this quality of public persistence have been explored in a rich seam of research on online networked learning (e.g., Adrianson, 2001; Hardy, Hodgson & McConnell, 1994; Kaye, 1992; McConnell, 2000). But the point we want to make here is that persistent, shareable online texts *afford* collaborative knowledge-building or knowledge-construction (Kovalainen & Kumpulainen, 2005; Pontecorvo, 1987; Scardamalia & Bereiter, 1991; Weinberger & Fischer, 2006).

We can now distinguish between educational designs for discussion-based activity that are primarily oriented towards bringing about change in World 2 (conceptual change in individuals) and those that are primarily oriented towards change in World 3 (improvement of conceptual artifacts). Conceptual artifacts, such as theoretical ideas in science, have an existence independent of any single inscription in a material artifact (such as a text) and independent of the cognition of any individual. However, they also *require* representation in material and cognitive forms for collaborative knowledge work to be possible. There is a special connection with online collaboration here. Face-to-face discussion can be used as a way of bringing about change in World 2 and it can be used to co-ordinate the construction of new or revised material representations of conceptual artifacts. Online discussion can also do this but, as we have seen, online discussion proceeds *through the construction of texts* (which we might class as digital artifacts renderable in a variety of material forms) and these texts can be representations of conceptual artifacts. This explains why a number of educational technology research and development teams around the world have developed computer systems that help an epistemic community collaborate in the improvement of conceptual artifacts, essentially by using a shared database of textual or multimedia notes. Examples would be Bereiter & Scardamalia's work in Canada on CSILE (Computer Supported Intentional Learning Environments) and Knowledge Forum (e.g., Scardamalia, Bereiter & Lamon, 1994) and, in Europe, work associated with the JITOL ('Just-in-Time Open Learning') and SHARP ('Shareable Representations of Practice') projects (Goodyear, 1995; Goodyear & Steeples, 1998).

Our own research
To what extent are students in higher education consciously involved in a *strong* version of collaborative knowledge building? We suspect that this is pretty rare, other than in cases that are so leading-edge that the teachers involved document what they are doing in the literature of innovative teaching and learning. Individual knowledge-building, in the strong sense, is not uncommon. It is the stuff of student research projects. Moreover, students in some discipline areas – notably the laboratory sciences – carry out their projects as part of a team and may have a sense of legitimate peripheral involvement in a larger knowledge-building community. But if apprenticeship in knowledge work – learning to think for a living – is to be available to most, if not all, university students then we have to find ways of engaging them in collaborative knowledge-building outside the lab-based subjects. And if we are serious about epistemic fluency, then students need to be legitimate participants in a wider variety of epistemic games. Perhaps this is happening, but without much publicity.

Over the last eight years we have accumulated a number of datasets through our interview and survey-based research into teachers' and students' conceptions of collaborative and discussion-based online and face-to-face learning activity. The datasets include full transcripts of in-depth interviews with 90 university students and 19 lecturers, as well as responses to open-ended questionnaires and rating scale instruments completed by over 400 students. The data have been gathered from courses at universities in the UK and Australia and in each case the course involved significant use of online discussion activity.

We have analysed this material using a broadly phenomenographic approach and have reported on relationships between conceptions of learning, approaches to study and engagement in online and face-to-face discussion (see Goodyear, Asensio, Jones, Hodgson & Steeples, 2003; Goodyear, Jones, Asensio, Hodgson & Steeples, 2005; Ellis, Goodyear, Prosser & O'Hara, 2006; Ellis, Goodyear, O'Hara, & Prosser, 2007).

For this chapter, we have worked through some of the interview transcripts afresh, looking for excerpts that reflect a consciousness of participation in knowledge-building in the strong sense. Our aim was to get an approximate sense of the frequency/rarity of such excerpts and to characterise the thinking about knowledge-building embedded in them.

We focused on two sets of transcripts and used concordance analysis to identify key words and phrases in context. The first set of transcripts came from interviews with 19 university teachers, each of whom had at least two years experience of using online discussions in their teaching. Each of these teachers had a local or national reputation for educational innovation and had taken up online teaching for pedagogical reasons, rather than because they felt a need to keep up with technological developments. The second set of transcripts came from in-depth interviews with 30 undergraduate students involved in courses that included a combination of face-to-face and online discussion.

Interviews with university teachers
This corpus of hour-long interview transcripts amounted to just over 150,000 words. The interviews were very loosely structured and invited the teachers to speak about the elements of course design and course experience that mattered most to them. The interviews were conducted several years after the publication of Allan Collins's ideas about epistemic forms, games and fluency. Nevertheless, we probably should not be surprised that the words 'epistemic', 'epistemology' and 'fluency' are entirely absent from the interview transcripts. There are no mentions of the names 'Collins' or 'Bereiter'; no mention of 'knowledge work' or 'apprenticeship'.

We began the hunt for mentions of collaborative knowledge-building by searching the text for the word 'knowledge'. There were 34 occurrences. None referred explicitly to 'knowledge-building' and just two referred explicitly to 'knowledge construction'. Both of these came from the same transcript (Teacher Q). The first mention was in a passage about how to assess students' online contributions. Teacher Q wanted to go beyond rewarding the *quantity* of student input:

> …we needed a more positive way of looking at what they'd contributed in terms of the knowledge constructional process not just what comes out at the end.. (Teacher Q)

It isn't clear from the rest of Teacher Q's transcript whether this 'knowledge constructional process' was something they saw as World 2 (the weak sense) or World 3 (the strong sense of knowledge-building).

In a later passage, they mentioned knowledge construction again.

> I'd like to develop more this idea that the way that knowledge is being talked about, used, collected, managed, constructed, transmitted, whatever um in a future which is dominated by quantity rather than quality you know that's a fundamental issue, I mean we talk a lot about knowledge extraction and collaborative knowledge construction and all the rest of it and in the end we still have experts deciding whether or not somebody has you know done it right basically and I don't think that is a sustainable model to be honest um somehow in our teaching… (Teacher Q).

Again, it's unclear whether Teacher Q is thinking of collaborative knowledge construction in the strong or weak sense. What is clear is that, for Teacher Q, collaborative knowledge construction is just something that is being *talked* about. It doesn't feature as they would wish in the course they teach.

Perhaps university teachers have other ways of talking about knowledge-building activities in their courses. Checking through all the other 32 occurrences of the word 'knowledge', we found it being used in a variety of ways, referring to the teacher's knowledge of their students, teacher's pedagogical knowledge, and – most frequently – knowledge as that which was to be taught and learned. Five occurrences came close on our theme of knowledge-building and apprenticeship in knowledge work. Two of these were from the interview with Teacher Q again, so we deal with these first.

> I would give credit to somebody who may be who's academic writing was not of the top drawer in the conventional sense but if they had used the medium in a way which either is an original way or a way that sort of created new opportunities for communication or new opportunities or new ideas about what sort of knowledge is being constructed in this process in a sense so somebody for example who opted to design a piece of multimedia could get a distinction for an assignment in which they produced a very good design and also a rationale for that design could get a distinction mark, but somebody who wrote a very good critique of another design um could also get a distinction mark (Teacher Q)

Teacher Q is referring to knowledge construction in World 2 *and* World 3. She is talking about what the student is learning through engagement in one kind of activity rather than another, but also about the inscription of conceptual artifacts in material (digital) form. That said, Teacher Q's focus is on (superficial) presentational rather than (deeper) epistemic forms.

The final excerpt is the closing passage from Teacher Q's interview.

> …we've got people here who are interested in knowledge management issues who are asking questions like 'what is in that, what is in the August data that we've got, all this discussion, three years of professional discussion amongst educational technologist about various about structured discussions about various issues, what's the knowledge that's in there, how do we find it, how do we define it and how do we get it out and what form do we have to put it into to make it accessible by anybody else'. That's a really important question I think or set of questions and if we don't do something about that we are kind of losing half of our opportunity to create

> new things about what we are doing rather than just making money out of it, not that I've got anything against making money of course' (Teacher Q)

This extract shows a belief that there's exploitable knowledge locked up in the transcripts of student discussions (the students in this case being professional educational technologists), but these thoughts aren't accompanied by any utterances that would lead one to believe that Teacher Q sees the strong version of collaborative knowledge-building as being *pedagogically*, rather than economically, desirable.

Two passages from interviews with other teachers also reveal some thinking about knowledge-building.

> 'the idea was that the group discussion is more interactive that they contribute that it's their page because you know when you listen to the small group discussions in the class they're fascinating. People are coming out with really interesting things, they are making excellent points and these are the sorts of things you want recorded up so that the group members have another source to draw on, OK they've got the books, they've got their work experience, they've got whatever and they've also got all their colleagues harvest knowledge, this is the idea' (Teacher D)

Teacher D is talking about their intention to capture some of the richness of face-to-face discussions in small groups when they redesign their online course next year. The reference to harvesting knowledge from colleagues reveals a view that students know things that are worth sharing, but this image of capturing what exists is a long way from the idea that students might collaborate to create new knowledge.

A more radical view of knowledge and knowledge creation appears in the interview with Teacher N.

> So we play around with different ways of relating to each other and different ways of thinking about creating knowledge and different ways of trying to express our interests in learning and teaching and that philosophy um is a sort of core of the whole course trying to open up peoples' ideas about learning and teaching, trying to shift them to think about what they are doing in their practice and reflect on their practice, by doing something interesting that involves them and causes them to question themselves and causes us as tutors to question ourselves (Teacher N)

Teacher N's course is a course about teaching and learning online. The students on the course are teachers. Teacher N has written a book and numerous articles about their approach to online learning. What they are saying comes close to our sense of epistemic fluency - 'different ways of thinking about creating knowledge' – but it has a reflective, 'hands-off' flavour that does not evince a commitment to having students *work* with different ways of knowing.

To summarise: we interviewed 19 innovative teachers to find out about the ways they made use of technology to support collaborative learning and about the intentions underlying their teaching approaches. In only a very small fraction of their utterances did they talk about wanting students to collaborate in knowledge work. We found very few signs of teachers wanting to talk about inducting students into the 'ways of knowing and thinking' characteristic of their discipline or profession. We found no traces of language showing a nuanced understanding of epistemic activity or epistemic forms. From such silences we infer that few, if any, teachers were setting out to create

opportunities for their students to be legitimate participants in knowledge work, peripheral or otherwise.

Interviews with undergraduate students

We started with transcripts of interviews carried out during 2005 and 2006 with students from a research-intensive university. These interviews asked about conceptions of, and approaches to, learning through discussion. We selected the subset of just 10 transcripts that included explicit reference to 'knowledge'. These interviews were typically 30 minutes long and the resulting corpus amounted to just under 34,000 words. There were 17 separate occurrences of the word 'knowledge' of which 14 were student, rather than interviewer, utterances. Unsurprisingly, none of the students talked explicitly about 'knowledge building' or 'knowledge construction'. The majority of the uses of the word 'knowledge' were bound to quantitative or accumulative conceptions of learning: that is, learning seen as an addition to one's knowledge, rather than as a transformation of one's understanding.

> I think the main thing is that you learnt something from the readings and you have your ideas… you've learnt some things from the readings but then being able to discuss it with other people online, and also in the tutorials, er I think you really get to see what they got out of it as well, which can be completely different and that adds to your knowledge. (Student B)

> And then online, for me that's just really seeing where everyone's at, what everyone kind of thinks. But it doesn't really, I don't think it adds that much to my technical sort of knowledge about the facts, you know, sort of thing. (Student J)

There were, however, three instances of talk about knowledge that took a different tack. Two of these talk about the way that other students' perspectives on issues can change one's own ideas about things.

The third and final quotation is more extended, including the interviewer's prompting questions (prefaced with an I). It is the one example from all our transcripts that comes close to capturing Collins' notion of epistemic fluency. This is in the first paragraph. The second half of this extract from Student C's interview also speaks to the idea of challenge leading to improved personal understanding.

> Student C: I think, I know that there is obviously no matter what I do there are going to be people who are a lot better, smarter and a lot more experienced than me so I always have an opinion but I also accept that there will always be people who disagree with me so it also helps me understand [how?] people who disagree with me think. So that if that does come up so for example in social work I am forced to act in a way which doesn't cohere with my personal beliefs. I am going to work with people who do believe that and how they behave and I can incorporate that into my work or whatever else I am doing.

> I: Right, right.

> C: Plus in my addition it also challenges my beliefs which is always good.

> I: Why is that good? Why is challenging your beliefs good?

C: Umm because a belief is something that is based on knowledge and experience and your understanding of the world and if it is being challenged you are testing it. Like if someone challenges my values there something they [inaudible] to myself but a belief is based on what I understand and if they challenge that I obviously understand things better and I believe that my understanding of whatever we are studying is closer, to relates more complete by having it challenged.

I: Right, so like if my belief is challenged, what?

C: If my beliefs are challenged I believe that my understanding of concepts are more complete.

This is the closest our data comes to reflecting Collins' notion of playing an epistemic game with, or against, people who are better than you at the game. It is a very rare example of a student, or teacher, talking about their activity as an apprenticeship in knowledge work. That said, it is still firmly in World 2. Its focus is on personal development, rather than the improvement of ideas in World 3.

Implications and conclusions
In some ways, our analysis is dismaying. Twenty-first century learning ought to give a central place to the development of epistemic fluency. Whether due to limitations of language or lack of ambition in pedagogy, we have found it hard to detect an explicit interest in this interpretation of the purpose of university learning.

We prefer to take a more positive view. From interviewing a small number of HE teachers in depth, and working professionally with a much larger number, we get a sense that most are still looking for convincing ideas about two major challenges: (i) how to ensure that their students are able to use their experiences of studying in a disciplinary context as a preparation for life in the modern world and (ii) how to make appropriate use of computer technology in support of students' learning. On the other side, students expect at least *some* aspects of their study experience to be useful in later life. They also expect to find themselves using computer technology at university, but don't have definitive views about *how* it should be used. We are in a period of experimentation and collective sense-making. Computer technology is already seen as offering some basic functionality: providing students with easy access to core data about a course, to reading lists and lecture notes, etc. Such uses are valuable and *may* be on a developmental path leading to pedagogically richer possibilities. What emerges from our research is a sense that those academics further down the path are still working out what they want to achieve through use of computer technologies, collaborative activities, online discussion, etc. If their practice was already crystallised, and the online space was already full of entrenched activity, there would be little scope for change. Our optimism comes from this sense of readiness for change – evident in teachers' demands for research-informed guidance - and for what might be achieved through a better realignment of technological capability and educational purpose. Articulating the characteristics of apprenticeship in knowledge work is a central part of this challenge.

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