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ARTICLE

Interdisciplinarity in Technology Enhanced Learning: An Interview Study

Eileen Scanlon* and Gráinne Conole†

This paper explores the influence of the concept of interdisciplinarity on the work of educational technologists and others involved in technology-enhanced learning (TEL) research. There is a growing recognition of the need for interdisciplinarity in solving complex research problems in many areas of science. Technology-enhanced learning is a relatively young area of research adopting a multidisciplinary approach to investigating the use of technologies for learning. This makes it a field that is worthy of exploration in terms of how the ways of working developed by its practitioners inform our understanding of the challenges of the field as well as its benefits. This paper reporting on work commissioned by the Joint Research Councils' programme on Technology Enhanced Learning provides a discussion of the growing literature on this topic, and a study of the working practices of academics in TEL research. An interview study of 18 participants was conducted as part of the project. The paper reports on the key findings from the interviews and concludes with some practical suggestions to help participants deal with the challenges posed by interdisciplinary working in TEL research.

Keywords: interdisciplinarity; technology enhanced learning; interviews; educational technology

Introduction

What is technology-enhanced learning (TEL)? TEL focuses on investigating how technologies are used for education and therefore draws on subject areas related to learning and teaching (education, psychology, etc.) and those concerned with technology (computer science, information sciences etc.), as well as conventions surrounding different subject domains. Does TEL research have particular theoretical allegiances? See Issroff and Scanlon, 2002; Conole and Oliver, 2002 for commentaries on this.

The approach taken to investigating the use of technologies for learning, brings together researchers with these various backgrounds to conduct multidisciplinary investigations.

In many areas, it has been recognised that, when working in an interdisciplinary fashion, there is the likelihood of making progress on complex problems, and there has been some discussion of the benefits of working this way. For example, the US National Academy of Sciences, National Academy of Engineering and Institute of Medicine report (2005) describes work on facilitating interdisciplinarity research as follows:

Interdisciplinary research is a mode of research by teams or individuals that integrates information, data, techniques, tools, perspectives,

concepts, and/or theories from two or more disciplines or bodies of specialized knowledge to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline or area of research practice (National Academies, 2005, 2).

Technology-enhanced learning is a term that has been in common use in the EU research community for the past 15 years. In that community, the difficulty of interdisciplinary working is also recognised in a Net4Society report on Social Sciences and Humanities (SSH) integration in Horizon 2020 (H2020). This report also makes some points on the novel approach taken in H2020, focusing on the societal challenges of embedding SSH in all specific objectives of the EU Framework Programme. Reporting on the interdisciplinary programmes, its authors concede:

In fact, the implementation of interdisciplinary research programmes is a challenge in itself. Traditionally, career patterns and academic institutions are structured along disciplinary lines. Interdisciplinary projects are usually more time-consuming as they need additional efforts to establish an integrated team and concept. Interdisciplinary funding programmes need to invest extra efforts to the programme design and to organising the evaluation of interdisciplinary proposals (Net4Society, 2014: 6).

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In the USA, the National Science Foundation comments on the difficulty of defining disciplines and the meaning of terms such as ‘multidisciplinary’ and ‘interdisciplinary’. They also comment that areas of research are ‘dynamic—continually emerging, melding and transforming’ and remark, ‘What is considered interdisciplinary today might be considered disciplinary tomorrow.’

The research objectives stated on the European Commission’s website illustrate their recognition of the importance of interdisciplinary working in high-level research. In the ex-ante evaluation of H2020, ‘The Grand Challenge’ report recognises the scale and importance of these approaches, in particular in terms of publications, saying that:

... the highest share of EU scientific publications involving cross-border European collaboration is found in ‘physics and astronomy’, ‘multidisciplinary sciences’ and ‘earth and environmental sciences’ ... and it is in these disciplines where one observes the highest impacts: in the five countries that publish a large part of all EU publications (Germany, France, the United Kingdom, Spain, Italy), publications in these disciplines are more frequently cited than a (world) ‘average’ publication in the same disciplines, and these disciplines are systematically among the disciplines with the highest impact scores in France, Germany and the United Kingdom ... [F]or most countries, ‘multidisciplinary sciences’ also rank very high in terms of impact, in particular in Germany, France and the United Kingdom, where it ranks first (European Commission, 2011: 5).

In the same document it is recognised that emerging technologies ‘are multidisciplinary, cutting across technology areas with a trend towards convergence and integration’. So it is already understood that a multidisciplinary approach is necessary to understand properly how technology performs, what its benefits might be, how people will interact while working on these projects and, particularly, what learning takes place.

There has also been relatively little research on the nature of knowledge creation in TEL settings, compared to interest in studying knowledge creation that has been demonstrated in other spheres of interest (Fong, 2003). On the other hand, there is a good understanding of the *need* for interdisciplinary working in TEL research in practical terms—for example, working in teams on projects (see, for example, Winters and Mor, 2008). An example of this is the work of Herodotou et al. (2015) on the development of a model of game motivation (MGM), a conceptual model explaining digital play motivation. In this study, a multidisciplinary approach was adopted where the choice of a mixed-methods research design was reinforced by the critical review of literature, revealing that a combination of evidence from multiple disciplines (psychology, sociology, technology) could contribute to a more comprehensive understanding of a player’s motivation in the project.

TEL research is often viewed as an open or relatively neutral field. In the ‘Beyond Prototypes’ investigation funded by the UK Joint Research Councils’ TEL

programme, an analysis of TEL projects is reported by Scanlon et al. (2014) which identifies two key factors in the success of such projects: ‘persistent intent’ (i.e. ideas working onward through successive funded projects) and the ‘TEL Complex’, an understanding of the complexity of the infrastructure around technology-enhanced learning. Nowotny (2001) sums this up well, quoting Taddai in her comment:

As Francois Taddai puts it: ‘No discipline knows more than all disciplines.’ If joint problem solving is the aim, then the means must provide for an integration of perspectives in the identification, formulation and resolution of what has to become a shared problem. One virtue you need when working in transdisciplinary research: patience. You must be very patient indeed ... To understand the language of other disciplines takes time (Nowotny, 2001: 1).

The importance of bringing a group together to work on such problems is recognised, and the nature of knowledge production in the work of such a group tends to be focused on the context of application. Barry and Born (2013) comment on this contemporary view of interdisciplinarity:

... what is novel is the contemporary sense that greater interdisciplinarity is a necessary response to intensifying demands that research should become more integrated than before with society and the economy. Interdisciplinarity has come to be at once a governmental demand, a reflexive orientation within the academy, and an object of knowledge (Barry and Born, 2013: 9).

Data collection and analysis methods

The dataset that was used to consider these issues is the interviews conducted with researchers in TEL as part of a Joint Research Councils’ programme investigating the cross-cutting theme of interdisciplinarity in TEL. We were commissioned to produce a study of the working practices of academics in TEL. An interview study of 18 participants, whose disciplinary backgrounds are illustrated in **Table 1**, was conducted as part of the project.

Table 1: Disciplinary background of interviewees.

Disciplines	
Science based	Mathematics (2) Chemistry (2) Physics (2) Engineering (2) Geography (2) Dentistry Computer science and AI (2) Maths and philosophy Psychology with Computing
Non-science based	Sociology and Economics English Literature Dance and Drama

These interviews ranged from 40 minutes to over an hour in length and were semi-structured with a relatively fixed set of questions (see **Table 2**). They were conducted through a mixture of media: face to face, via telephone or over Skype (see **Table 3**).

The initial set of questions arose from a seminar and discussions on a Networked Learning hot-seat forum and a forum discussion on the Cloudworks site, and from themes emerging from the literature review. The questions were constructed to explore an interviewee's experience in interdisciplinarity in TEL, and the nature of interdisciplinarity, specifically in Technology Enhanced Learning. The contributions to the fora were reviewed to identify themes of interest, and after the interviews were conducted the interviews were transcribed. These transcriptions (and their associated recordings) were then reviewed

and a thematic analysis (see Braun and Clarke, 2006) was conducted across the dataset of interviews. The research team then jointly reviewed three of the transcribed interviews to agree on a set of emergent themes to identify themes for further analysis. A document containing a list of 22 themes was created. This covered interdisciplinarity in areas such as the origins, experiences, challenges, benefits and methodologies of the interviewees. The interview transcripts were manually tagged and copied to the appropriate theme or themes. The 22 themes were then aligned into five groupings:

- origins and career trajectories
- influences, beliefs and theoretical perspectives
- methodologies, methods and tools
- challenges to interdisciplinarity
- benefits of interdisciplinary working.

Table 2: Extract from interview schedule.

1. What is your birth discipline?
2. What theoretical perspectives do you use in your research?
3. What methodological approaches do you use in your research?
4. TEL is interdisciplinary by nature, what challenges does this give us?
5. What are the grand research challenges/questions facing networked learning?
6. Share case studies demonstrating different theoretical and methodological approaches

Although this was a relatively small sample of interviews, the data they produced was rich and detailed. (One aim of the exercise was to identify themes that would be worthy of future investigations.) There seemed to be no uncertainty among participants about the importance of interdisciplinarity among interviewees, either, with one interviewee commenting:

You can't escape interdisciplinarity if you're wanting to make a difference in the world, designing artefacts that are going to improve people's lives (Interviewee I).

Table 3: Summary of interview participants, background and interview media.

Reference number	Job title	Background	Interview media
A	Professor	Educational Technology and Chemistry	F2F
B	Professor	Educational Technology and Physics	Phone
C	Senior Lecturer	Educational Technology and Maths	F2F
D	Professor	Learning Technologies	F2F
E	Senior Lecturer	Knowledge Media	Phone
F	Professor	Educational Technology (Science Studies)	Phone
G	Professor	Human Computer Interaction	F2F
H	Lecturer	Educational Technology Practice based learning	F2F
I	Professor	Learning Sciences	F2F
J	Reader	Human computer interaction	F2F
K	Professor	Dentistry	Skype
L	Professor	Educational Technology	F2F
M	Reader	Education	"
N	Reader	Psychology	"
O	Professor	Computer Science	F2F
P	Professor	Education	"
Q	Professor	Maths Education	F2F
R	Professor	Education	"

Findings

As mentioned in the previous section, the disciplinary background of the interviewees has been annotated in **Table 1**. In the material that follows, this background is referred to as 'home discipline' or 'birth discipline'.

In terms of location, the researchers were spread across a range of different departments; some were located in individual cognate discipline departments, such as education or computer science, while others were located in what might be termed 'central services', and one other was located in the subject area of dentistry). All, however, had had involvement in TEL research.

One interviewee captures the essentially complex picture of the type of setting in which TEL projects operate:

We are very much looking at the way, the process, by which children learn rather than the knowledge they glean through technology intervention, and this involves doing 'in the wild' studies. So it's, you know, observing them, asking questions, setting hypotheses, and how they engage with the technology in the external world, how they engage with each other and how they decide what to do next. And that is very messy to study, and so we have developed ways of analysing conversations, interactions with the technology and what they create and how they interact with the world (Interviewee F).

Comments from interviews could be grouped into a number of themes: leadership, the benefits of interdisciplinarity, its challenges and the nature of interdisciplinary working.

Benefits of interdisciplinarity

Most interviewees could refer to the positive aspects of interdisciplinary team working, in particular that it enabled cross-fertilisation. Two interviewees mentioned the benefit of looking at problems through another's eyes:

I really enjoy understanding how other disciplines think because trying to see the world through a different person's eyes is ... really exciting for me (Interviewee E).

One of the benefits is having different rich theoretical and methodological perspectives and looking at the same shared problem space from different eyes (Interviewee A).

There was reference to the current popularity of the idea of interdisciplinarity:

It's something within the zeitgeist, at the moment, that we should be interdisciplinary or aspire to be interdisciplinary (Interviewee F).

More specific benefits were attached to the opportunity to make advances in working outside one's own discipline:

... several years ahead of how they might have done if you had waited for your own discipline to get on that particular track ... (Interviewee X).

One commenter could see the way in which challenges from outside one's own discipline could cause this advance:

And equally we are testing the computer scientists as well, because we're making them think about what's going on in a learning environment in a way they've never had to think about before. So there's, I mean there's lots of stuff in the computer-science literature about ontologies and learning-design systems. They've got formalisms and specifications, elearning specifications and so on, which are all built on a kind of fantasy about how education is conducted. It's a sort of idealised conceptualisation of what teachers and learners do together. It's not real, and that's what we bring to that kind of work, I think. So there's been a complete separation, really, in the way that that computational end of learning design has developed, and the way in which teachers and learners actually behave (Interviewee J).

The most positive of views was that something new is created in the process of working with others from different disciplines:

There is integrity and strength in each of the different perspectives, but when they are woven together you get a tapestry (Interviewee E).

Challenges to interdisciplinarity

A number of areas were referred to in the interviews as particularly challenging. These included communication, publication and funding, the nature of interdisciplinarity, and disciplinary silos. These are discussed below.

Communication

Communication was a particular issue, with the commonly held view that interdisciplinary ways of working need time to come to fruition:

You have got to be prepared to invest time and energy into working with the team rather than just doing your bit (Interviewee L).

Interviewees referred to the need to spend time on understanding team members coming from different disciplines, in particular to developing shared understanding – a notoriously difficult prospect for academics. As Interviewee A commented, 'One of the challenges for an academic is to be unafraid of saying, "I don't understand," and hence being amenable to working with others to develop a shared vision and language. Indeed, the importance of developing a shared vision and language came up in several interviews, for example:

In all the major projects that I have worked on, we have struggled to establish a common language so that the people from different disciplines can talk to each other (Interviewee M).

We all mean different things by the words we use (Interviewee J).

Sometimes weeks can go by before you have realised you are speaking the same words but talking in a different language (Interviewee J).

Publication and funding

The interviews revealed a set of concerns among participants about the place of publication and sources of funding for interdisciplinary work:

I seriously doubt that the real audience for anything I do is actually in the field where the research was originally conducted. So unfortunately the current assessment regimes don't look very kindly on that (Interviewee I).

This comment refers to the difficulty of finding an audience for such work and concerns of having research published by journals that might not be rated so highly in research exercises, and how this might impact on researchers' careers. Interviewee J also expressed this concern by saying, 'There isn't a right journal really for us.'

The participants revealed that one approach to addressing these concerns was to confront the difficulties but to concentrate on reporting back work to their home discipline:

What we also have to do, interestingly, is to sell our line in other contexts, in the disciplinary context (Interviewee J).

This tension is also an issue when it comes to applying for research funding:

If you submit an interdisciplinary idea for funding, you just sort of pray that reviewers who are sympathetic to it are going to get assigned and are going to bring criteria that resonates with yours (Interviewee E).

Each of the challenges described above can be a disincentive to forming interdisciplinary teams.

The nature of interdisciplinary working

A few of the interviewees had a more nuanced view of interdisciplinary working, some making comments about the nature of the work that was being done, based on their experience of working on projects. One commented:

In reality, a lot of what is labelled interdisciplinarity is in fact pseudo-interdisciplinarity or parallel playing (Interviewee R).

Others recognised that:

Authentic interdisciplinarity is rare and is very hard work (Interviewee P).

These comments relate to ongoing discussions in the literature about the distinctions between multidisciplinary working and the lip service paid to the concept of interdisciplinarity.

Disciplinary silos

Several comments were made about the view of interdisciplinarity and interdisciplinary working from the position of others within the interviewees' home discipline. One commented:

I was definitely in the science camp of where the world is known and science is best and everything else is woefully rubbish and how could the concept of doing an interview with somebody count as data? It took a long time to shift that belief set, but I think I'm probably stronger as a result because I can now see both camps (Interviewee A).

Some interviewees, meanwhile, recognised personality features that they thought applied to those with a taste for interdisciplinary working:

It's a certain kind of intellectual curiosity and a lack of patience for doing the same thing over and over again (Interviewee I).

However, some interviewees were concerned that responses based on disciplinary perspectives could sometimes be responses from within disciplinary silos. For example, the two following quotes refer to these types of difficulties:

I think there is a real lack of understanding and possibly respect between the computer scientists and educationalists and psychologists (Interviewee K).

There is an aristocracy amongst the disciplines that sometimes can be damaging to interdisciplinary working (Interviewee D).

Some participants saw this respect for the home disciplines of others as a key feature of interdisciplinary working:

The hallmark of interdisciplinarity really working is when it starts to influence what you do ... I think that another hallmark of successful interdisciplinarity is respect for the methods and knowledge of your interdisciplinary colleagues (Interviewee P).

Disciplines have a role in knowledge production. Indeed, Krishnan (2009), citing Fuller (2003), considers that 'Disciplines and the disciplinary organisation of knowledge could turn out to be "a necessary evil of knowledge production".' (Krishnan 2009: 20). This is a contrasting view to arguments for the importance of interdisciplinarity (see for example Forster, 2003).

Theoretical perspectives

In the interviews, a range of theories and cultural approaches were cited as being important – in particular the work of Vygotsky (1978), Engeström (1987) and others on Activity Theory – and a broad body of literature was drawn on from across different disciplines. It revealed that the field of TEL is indeed at least multidisciplinary, because these texts are drawn from a wide number of disciplines that can contribute to 'TEL'. Indeed the term 'technology-enhanced learning' itself is the subject of much discussion, with commentators such as Bayne (2014) being critical of its unproblematic use as 'a descriptive shorthand for what is in fact a complex and often problematic constellation of social, technological and educational change' (Bayne, 2014: 5).

However, there is another important aspect to the nature of interdisciplinarity in TEL research, in terms of both the actual processes involved and how individuals interact within teams, with benefit from working with other researchers. Many of the TEL researchers interviewed felt that it was the way of working itself that was the most influential aspect which influenced what they produced. These participants found that working with others in an interdisciplinary fashion had a larger impact on them than that of an influential individual from their birth discipline or an individual textbook or article they had read.

During the interviews, TEL researchers brought up their own background and theoretical perspectives to help to contextualise the research they undertake, for example:

I'm interested in exploring other perspectives because we don't think they are adequate enough for what we need, so we are developing our own theories (Interviewee A).

These comments raise the issue of how theories could be integrated or developed in the field of TEL to produce a composite or underpinning educational-technology perspective. This consideration of the potential for new thinking and the emergence of new methodologies links back to the notion of interdisciplinarity as being deviant or transgressive and its ability to challenge existing assumptions (Nowotny, 2001; Moran, 2010). One would hope that a relatively new field such as TEL as part of educational technology would be built on such endeavours.

Many TEL researchers expressed the view that they believed their research work was unlikely to be addressed adequately – or fully understood – within a single disciplinary approach, and hence that there is a need for a portfolio of mixed methodologies/methods to be selected and combined for interdisciplinary research. An emergent tradition for interdisciplinary research involves the combination of complementary methods. One example of this is when interviewees reported experience of such 'mixed method' projects that placed equal value on both qualitative and quantitative approaches (Greene and Caracelli, 1997).

Discussion

This study has identified a number of perceived benefits of undertaking interdisciplinary work in TEL research. These included capitalising on the breadth of different theoretical and methodological perspectives brought by

team members to address key research challenges. Working in interdisciplinary teams was also cited by many as beneficial in terms of broadening their research perspectives, inspiring them to become aware of additional literatures to those with which they were most familiar and having others with different perspectives to bounce ideas off and challenge them. The need for a core shared vision and strong leadership were also cited as important factors for success.

Tensions, however, are also evident: it is often difficult for researchers to develop a shared common language, and that building a strong team requires time and trust. Institutional and professional barriers are also evident. Single discipline research is generally more highly regarded in terms of research excellence initiatives, and much interdisciplinary research is often accused of being methodologically muddled or less rigorous than work done within disciplinary norms. This has been recognised in previous work, including that of Klein (1993), who observes:

Researchers who identify themselves professionally with cross-disciplinary categories face the entire panoply of gatekeeping mechanisms, which by and large favor existing disciplinary categories (Klein, 1993: 193, also quoted in Nissani 1997).

Our review of the literature on interdisciplinary working and how it works out in TEL research allows us to make some recommendations for strategies to adopt to meet the challenges identified here.

In terms of supporting, communicating and documenting interdisciplinarity, it is evident that a number of strategies can be adopted. Firstly—and perhaps most importantly—is the need to ensure that there is effective communication across the team. The different perspectives amongst team members need to be articulated and interrogated in light of the research questions being addressed. An ongoing iterative process of dialogic engagement and critical reflection is needed so that a team can come to some degree of shared understanding and consensus. The time and effort needed to achieve this should not be underestimated. Technologies also have the potential to act as powerful mediating artefacts (Conole, 2013) in this process by providing mechanisms for sharing and documenting understanding. They can act as a prompt for debate and as a digital trial of the discourse within the team. The choice of which technologies to use will have an impact on the nature of the discussion and the collaboration; interactions in and through a wiki are very different to, for example, those conducted on a collective blog.

Secondly, team dynamics are clearly important, but the role of the principal investigator, in particular, is perhaps even more important for interdisciplinary projects than for those based in a single discipline. (This relates to previous comments about the importance of leadership in such projects.) The project lead needs to be sensitive to group dynamics and to foster a culture of trust and shared enterprise. Articulation of a common vision for the research right at the start of the project can help with this, as can the ongoing dialogic exchange discussed above.

Thirdly, capacity building is likely to be important, in terms both of helping individuals to develop the skills and competences they need to adopt interdisciplinary approaches, and of using new technologies as effective tools. The challenges for early-career researchers whose first post-doctoral experiences were in such multidisciplinary settings were recognised by the TEL–TLRP (Teaching and Learning Research Programme) – see, for example, Carmichael (2007, 2009) and Scanlon (2015).

Conclusions

Interdisciplinarity is a core feature of TEL research, according to those who commissioned the TEL–TLRP and many other commentators on contemporary approaches to research. TEL researchers are drawn from a broad range of disciplines and bring with them a rich variety of theoretical perspectives and methodologies. These have the potential to be harnessed in order to provide real insights into some of the challenging research questions being asked that are contemporary in the field of TEL. The researchers who participated in this study provided some references to theory formation, and some recognised that the outcome of such work often leads, over time, to the distinctive features of a new discipline.

Scanlon and Taylor (2016: 6) argue that ‘Technology-enhanced learning consists of much more than a set of research-informed products. It is a complex system, which includes communities, technologies and practices that are informed by pedagogy (the theory and practice of teaching, learning and assessment).’ This emphasises the complexity of the situations in which people are working. This complexity is recognised in the ‘TEL Complex’ examined in ‘Beyond Prototypes’ (Scanlon et al. 2013), a system description of the ‘TEL complex’ in which an ecology of practices and technology innovation are involved.

We began this inquiry by referring to a widespread belief in the need for TEL projects to work in an interdisciplinary fashion in order to find solutions to new research questions. We perhaps unsurprisingly found agreement with this view among those who had worked in technology-enhanced learning, together with a realistic view of both the benefits and also the challenges of working in this way. This paper has contributed to our understanding of these benefits (including a better understanding of the role of technology in facilitating interdisciplinary working in technology enhanced learning research). It also points to the challenges such as the dilemmas for interdisciplinary workers in journal publishing.

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Competing Interests

The authors have no competing interests to declare.

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