Interdisciplinarity and technology-enhanced learning: Reflections from art and design and educational perspectives

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Abstract
The main focus of this article is our project of reimagining higher education for ourselves and our students using the central theme of technology-enhanced learning (TEL), which is inextricably linked to education in the present and in the future in many contexts. We argue that interdisciplinarity and interdisciplinary working are central and essential features of TEL and, yet, they are largely invisible in the TEL literature. TEL itself is still largely invisible in the sociology of education literature and, hence, suffers 'dual invisibility'. We suggest that this may be connected to the crisis that has beset TEL research and pedagogy. We examine the power of theory in TEL work, citing the use of cultural–historical activity theory (CHAT) in our own TEL work. A detailed account of an interdisciplinary, theory-informed TEL project is provided, and this is analysed to explore how the weave between disciplines, particularly art and design, and education, and interdisciplinary project working can be mutually beneficial in our project of reimagining higher education for work and study.

Keywords
Interdisciplinarity, creativity, art and design education, technology-enhanced learning (TEL), theory, cultural–historical activity theory (CHAT)

Introduction

> the question of pedagogy [is] central to a reformulated politics that reclaims the university as a democratic public sphere. Pedagogy plays an important role in linking politics to matters of critical agency and social transformation. In this instance, pedagogy is integral to any discourse about academic freedom; but, more

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> important, it might very well be the most crucial referent we have for understanding politics and defending the university as one of the few remaining democratic public spheres in North America today. As Ian Angus rightly argues, 'The justification for academic freedom lies in the activity of critical thinking', and protecting critical thought must involve safeguarding the pedagogical and political conditions that make it possible.
>
> (Giroux, 2011)

There is little doubt that the nature of higher education, academic life and work is changing, both for staff and students. It seems to us that this is a complex array of global phenomena, with many aspects. Giroux considers pedagogy to be a central element of these changes (Giroux, 2011). We think that they are also inextricably linked to technology-enhanced learning (TEL), both its pedagogies and its research, because many of the changes are animated and facilitated by the same forms of digitisation that support TEL. We think there is a need both to theorise and organise in the face of these complex and emerging realities. One of the tasks with which we are challenged is to 'reimagine' the nature of our work, and with it the nature of TEL. It is our hope that this article may be a further contribution to that process. In earlier work (Sclater and Lally, 2017) we commenced the task by looking explicitly at interdisciplinarity in relation to TEL. We reported on the central role of art and design education in bringing creative practices into informal TEL learning communities, and talked with researchers who were members of an interdisciplinary TEL team in Scotland (Sclater and Lally, 2016a: 865).

In this article, we have expanded this focus, in part, by looking at the wider features of interdisciplinarity because we are concerned about its academic 'invisibility' in TEL discourse. One of the challenges of reimagining our working and learning futures is to understand the conditions of our work as TEL researchers and educators. We think that interdisciplinarity is a key to developing this understanding in that it identifies some of the associated problems and promotes solutions. It is this project with which we are currently engaged. In a fascinating account of an experiment to bring together social and environmental scientists in an interdisciplinary collaboration, Evans and Randalls (2008) recollected their experiences of the difficulties of definition, implementation and sustainability of their interdisciplinary working. This was in part because of the 'disciplinary hierarchy', the feelings of 'loss of analytical grip' of some experts in the group and the need to accept some loss of control in a more polyvocal research setting. These are some of the issues we try to illuminate in the following account.

There are, of course, institutional as well as individual and research group difficulties in working in interdisciplinary ways. In a reflection on university-wide attempts to support this style of working, Franks et al. (2007: 174) identified 19 'barriers to interdisciplinarity'. They observed that their institution failed to report interdisciplinary success stories, or acknowledge its interdisciplinary history and learning. This was also compounded by the dominance of disciplinarity (Franks et al., 2007: 183–184). All of this occurred in an institution that had been specifically founded to foster interdisciplinarity.

These trends may seem to be directly in tension with our project of reimagining academic and working lives, including teaching and research. Yet, this project is partly driven by individual academics' lived experiences of 21st-century higher education environments (Beetham, 2015) and the role of digital technologies in their globalisation. This situation – the relative 'invisibility' of interdisciplinarity – may also be compounded by the invisibility of digital technologies more widely in the sociology of education (Selwyn and Facer, 2014). We call this the 'dual invisibilities' of TEL, both in relation to its ways of working and its theorisation within a wider field. The following account, from the literature and our own experiences, is a 'weave' of our discipline-based

experiences to interdisciplinarity and back again that merges our two interdisciplinary journeys and the related challenges of theorisation.

In the remaining sections, we first consider some of the wider issues of interdisciplinarity and of our own backgrounds. The exigencies of the sheer pace of educational, economic and political developments have 'coerced' us into a pragmatic and 'human-scale' approach to this analysis. In this process of coercion, the article is structured as a reflection on our joint experiences of the challenges and opportunities pertaining to 10 years of shared research in the field of TEL. This reflective process has led to a consideration of issues at the confluence of some of our own work in this field and the emergence of some areas of activity that we would like to argue are relevant to the future of TEL and, perhaps, learning in higher education more generally, although we do not claim this; we are making no bold claims. There is too much that is unpredictable about the future of higher education at this time. It is by no means easy to find reflections on and reviews of the field that encompass a significant personal element, a historical element, or a narrative of personal reflection that attempts to offer a human-scale cluster of 'useful' insights. It may also be the case that we have become somewhat alienated from the grand narrative approach by our recent experiences in the field (see Hall, 2017 for further details of this). From our current perspective, our reflective narrative may be as far as we can take our analysis at the present time. We beg the reader's indulgence, and hope that some insights of practical use may be gleaned from this approach. We leave the reader to make this judgement and correspond with us accordingly.

Interdisciplinarity – creativity, immigrants, disciplinary weakness and network activities

A useful way to start then, for us, is with 'interdisciplinarity'. It has been one of the more intentional aspects of our own 'research programme' as we have developed an increasingly conscious attempt at 'interdisciplinary fusion' – bringing together a range of disciplinary strands in our work, and that of our collaborators. For us, this programme has been, and is, an ongoing process of trying to create imaginative, open-ended and informal learning experiences and environments that sup-port the development of multiple learning possibilities and potential among a wide range of participants. Interdisciplinarity has been one of the key 'ingredients' for us in this work, principally because it has provided a constant source of ideas and creative possibilities. This approach has given us the insight to work confidently and simultaneously with computer scientists, educational psychologists, art and design experts, educational researchers and network technologists, and has enabled us to blend this expertise into new forms of education.

Our own interdisciplinary directions of thinking with regard to TEL were eventually given very extensive support by the third phase of the UK's Teaching and Learning Research Programme (TLRP3 or TLRP-TEL), which funded our Inter-Life project (Technology Enhanced Learning, 2012; Xube, 2011). See section entitled 'A TEL interdisciplinary project – Inter-Life' later on in the article. TLRP3 was entirely devoted to TEL (Technology Enhanced Learning, 2011), and had a significant team of leading interdisciplinary experts from many backgrounds (Technology Enhanced Learning, 2013). It was funded jointly by two of the Research Councils UK's (RCUK) leading research councils, the Economic and Social Research Council (ESRC) and the Engineering and Physical Sciences Research Council (EPSRC), which together facilitated our interdisciplinary research activity across the social and physical sciences.

Increasingly, we feel that an interdisciplinary approach can open up many new possibilities. Using interdisciplinarity has its own challenges, however, and not least among them is that of

sustaining funding. The significant funding from the TLRP-TEL programme (£12 m) ended in 2012, just at the point at which eight major projects had come to fruition (Technology Enhanced Learning, 2017) and the thematic priorities of ESRC/EPSRC changed towards the acquisition of large datasets. This signalled a move away from their former emphasis on teaching, learning and education. However, there is still some recognition, in the UK at least, that interdisciplinary work has a role to play, but funding is again an issue. Another challenge, for us, has been that this way of working can reduce one's own sense of perceived 'expertise', both personally, and among colleagues. The fundamentally interdisciplinary nature of TEL research was addressed by TLRP-TEL itself (in one of its cross-cutting themes), and some of the more TEL-specific aspects of these issues were examined in some depth (Conole et al., 2010).

Interdisciplinarity has been too little explored or examined, and we have struggled in our work to find adequate and useful accounts that set out the issues in ways that practitioners can explicitly use. Nissani (1995, 1997, 2016) is one of a small number of writers who have addressed the wider issues of working and thinking in interdisciplinary ways. Nissani's writing is fundamentally pragmatic and, we think, in this way he makes the approach accessible. In his 'Interdisciplinary journeys' keynote address, Nissani cuts through the complexities of terminology to help in understanding what is involved. For example, he explains a 'discipline' as: 'any comparatively self-contained and isolated domain of human experience which possesses its own community of experts, e.g., music, physics. With time, such broad disciplines maybe subdivided, e.g., classical music, nuclear physics' (Nissani, 2016: 2). From this standpoint, it is straightforward to see that 'Interdisciplinarity is best seen as bringing together distinctive components of two or more disciplines' (Nissani, 2016: 2). Another key element of understanding relates to the domains (realms) in which interdisciplinarity can be applied. Nissani (1997) argues that, 'In academic discourse, interdisciplinarity typically applies to four realms: knowledge, cultural innovations (e.g., scientific research, writing novels), education, and theory.' There is a further dimension relevant to a pragmatic understanding that may help in evaluating the contribution of interdisciplinarity to an endeavour – that of richness: 'The interdisciplinary richness of any two instances of knowledge, innovation, or education can be ranked by weighing four variables: number of disciplines involved, "the distance" between them, the novelty of any particular combination, and their extent of integration' (Nissani, 1995). Nissani also provides a useful summary of some of the key advantages of interdisciplinarity. We will briefly consider three of these: creativity, outsider perspectives and disciplinary weaknesses. Nissani (1997) argues in his seminal paper 'Ten cheers for interdisciplinarity' that creativity, in the widest sense, often requires interdisciplinary knowledge. Previously unrelated ideas can lead to significant insights when brought together in the same cognitive frame. In our own work, the fusion between art and design education and informal lifeskills education in the Inter-Life project (see section entitled 'A TEL interdisciplinary project – Inter-Life' later on in the article) is probably the most obvious productive example. Nissani cites multiple historical examples. The most prominent of these is probably Thomas Kuhn (1970), who, in noticing the similarity between the idea of the 'gestalt shift' in the psychological domain, and the way shared understandings of an area of science could shift dramatically and collectively, formulated the seminal idea of the 'paradigm shift' in the history of science. In another example, Nissani cites C. Wright Mills who, in his discussion of the development of sociological imagination (1959: 211–212), argued that its development required considerable routine work. However, he also argued that it emerged from a combination of ideas that had not previously been brought together with a playfulness of mind or a very strong drive to make sense of the world. It was also supported by a toleration, at the very least, of ideas from a range of disciplines.

In the second area, that of outsider perspectives, Nissani (1997: 204) observed that immigrants to a field often make significant contributions to it. He calls this 'the outsider's perspective'. He

cites as an example the 'phage group' of biologists doing cutting-edge research on viruses in the mid-20th century. In the 1950s, molecular biology had been transformed by mass migration of physicists into the field. Seventeen of the 41 scientists in the phage group were either chemists or physicists. One explanation he offers for the research power of the group was that the 'immigrants' brought with them new methodologies and insights. Furthermore, these 'immigrants' brought a different vision that enabled them to see anomalies – 'invisible' features of the investigation – and, therefore, were able to reframe elements of the findings that habitués of the field simply missed or could not see at all. He also argues that these outsiders' perspectives can be of particular value in times of disciplinary crisis. It could be argued that education has suffered several such crises (Amano, 1998; Amano and Poole, 2005; Anderson and Herr, 1999; Bereday, 1969; Blumenstyk, 2014; Bush, 1999; Corwin, 1974; Garegae, 2008; Losen and Skiba, 2010; Stewart, 1993) and may well have been in a particularly difficult crisis from the 1970s until the present time. We will say more about this in relation to TEL in Section 4 (see also Lally and Traxler, 2016). Nissani cites the existence of many controversies and methodological disputes as evidence of this 'unsettled state' (Swoboda, 1979: 81). Newcomers, Nissani argues, may be keener to act in creative ways to resolve a crisis than habitués in a discipline. The 'paradigm wars' dispute is a good example in education (see Gage, 1989 and Hammersley, 1997, 2008).

One of the problems of 'disciplinarity' is that of 'disciplinary weakness'. As disciplines become more specialised they become increasingly isolated from areas from which they may have earlier drawn paradigmatic examples, methods or theory. This is a common enough problem in the social sciences. As an example, sociologists, Nissani argues, long continued to base their understandings of primitive societies on Ruth Benedict's *Patterns of Culture* (1934). This led to a situation in which sociologists were still making significant use of her work, long after anthropologists had moved on from Benedict's ethnographic analyses. This situation does not deny the intriguing quality of her conceptual scheme, Nissani argues. However, it does mean that the historical and ethno-graphic accounts are no longer empirically valid. Wax (1969: 81–82) points out how this kind of isolation between disciplines may lead to reliance on theories and data that are no longer accepted in the originating discipline. This isolation, and intensity of activity in a small area, leads to loss of contact with key ideas that could inform current and future work. Nissani argues (1997: 206) that these kinds of disciplinary difficulties can occur even in research of the highest quality, and that they are a 'core', if unwelcome element of scholarly work.

In a hypothetical world of 'pure disciplinarity', it would, of course, be exceedingly difficult to locate these kinds of errors. Other members of the discipline would be similarly limited by the lack of breadth and vision. They would, therefore, be, in effect, 'blind' to the problems. By the same mechanism, those in the sister disciplines would not see them either. Because of the extent to which these kinds of problems are identified ('cross-disciplinary oversights'), we may have some measure of inter-disciplinarity as still alive and well. Thankfully, we mostly do not live in this hypothetical state of disciplinarity. However, as this brief example shows, things are still a considerable way from a 'healthy interdisciplinarity'. In the TEL field, it seems to us, interdisciplinarity can pay huge dividends, as evidenced by the TLRP-TEL programme. We will look at one of the projects in more detail in Section 5.

In a final reflection on interdisciplinarity, for now, we observe that, as citizens, we are under more pressure than ever before to understand 'reality as a whole', as Nissani puts it Nissani, 1997 p210. We also feel this pressure as educators, and as researchers. It seems clear to us that we no longer have the luxury of operating in narrow disciplinary areas, either professionally or person-ally. There are too many crises demanding our attention and requiring creative solutions that call for thinking beyond disciplines. Our recent work on sustainability in art and design education (Sclater, 2016) and in computer science education (Lally and Donaldson, 2018) is, we hope, taking this approach in new directions to address crises in the field of education relating to education for

sustainability in art and design, and the teaching and learning of computing science in ways that are aware of the social and economic implications of this field. To illustrate this, we take another example of very serious concern to our survival: environmental crisis and anthropogenic climate change. At the end of the interdisciplinary Inter-Life project we decided that we might productively take a similar approach to climate change issues in higher education and we conceptualised a research network that would primarily be focused on exploring pedagogies of 'socio-ecological sustainability' for multiple disciplinary contexts in higher education. One of our aims is to support experts to move beyond their disciplinary expertise, and create new, interdisciplinary pedagogies. This thinking built upon the International Journal of Art and Design Education (iJADE) Conference held at the Glasgow School of Art in November 2015 (Adams, 2016). The international experts at the 2015 conference (including researchers, teachers and practitioners in higher education) considered a range of issues around socio-ecological sustainability, the use of creative practices to sup-port dialogue and the urgent need for new pedagogical practices to address socio-ecological sustainability.

Nissani (1997) has argued that 'Interdisciplinarity typically applies to four realms: knowledge, research, education, and theory.' These realms are central to pedagogical research. The crossing over between them is a major source of ideas for building new learning environments. Interdisciplinarity, then, at its most basic, brings together the distinctive components of many disciplines (Nissani, 1997: 203).

The research network was conceived to bring together an interdisciplinary team of creative practitioners and cross-disciplinary researchers so that they could engage in a joint (interdisciplinary) research project focused on the pedagogy of socio-ecological sustainability. One key element of this approach is that the network will use creative practices as the 'shared language' to facilitate communication between participating researchers. Our recent research (Sclater, 2016; Sclater and Lally, 2016a) had highlighted the need for novel and creative ways to mediate interdisciplinary communications in order to support collaborative working. We have also shown that creative practices can offer a powerful language for such collaborative communication (Lally and Sclater, 2012, 2013; Sclater and Lally, 2013, 2014). The network's principal aim, as we conceptualised it, will be to use creative practices with disciplinary experts who are collaborating towards the shared goal of socio-ecological sustainability to support their interdisciplinary communication and investigation in order to create new pedagogical resources.

Recent scientific evidence has clearly shown the need for urgent action on issues of socio-ecological sustainability. Hansen et al. (2016: 3801), for example, said:

> There is a possibility, a real danger, that we will hand young people and future generations a climate system that is practically out of their control. We conclude that the message our climate science delivers to society, policymakers, and the public alike is this: we have a global emergency. Fossil fuel CO_2 emissions should be reduced as rapidly as practical.

As we develop this idea, the project team will focus on conceptualising interdisciplinary, research-informed and creative pedagogical practices. The intention is that these will address socio-ecological sustainability within multiple higher education contexts, employing co-design, with potential end-users as a key element of the process. A second project aim will be to focus on identifying the characteristics of learning spaces (real spaces and online spaces) that support the use of creative practices (for example, photography, film, performance, environmental art). We know from our own Inter-Life work that research communities can flourish in these spaces and they become important for undertaking research. New approaches combine traditional creative techniques and new technologies in pursuit of shared interests and new possibilities for research. This kind of

collaboration can occur between inquisitive partners from different fields. The network will also aim to focus on different uses of these spaces for interdisciplinary communication and to support the role of TEL in enriching these communication processes.

The visual arts have become increasingly prominent in research, as awareness has increased of their potential to reveal and help us understand aspects of reality more profoundly. Sullivan (2006, 2010) has argued that artistic forms of knowing help all of us to understand the complexity of our world, and express this creatively. The interdisciplinary network we have outlined here will create and consolidate collaborative partnerships and cut across the arts, humanities, social sciences and sciences.

Knowledge exchange and co-design are key elements of our network thinking. Indeed, they are integral to the development process. The exchange of ideas between users and creators of research as an ongoing process of co-creation is, we think, vital to the success of the network. Through engagement with key stakeholders during the development cycle, the ideas and needs of those who could benefit most from the outcomes of our network will be welcomed and invited with participation in 'conversaziones', in which the network's key ideas and work in progress will be shared, critiqued and refined. Later in the lifecycle of the network its key outcomes will be made accessible to non-specialist audiences in a variety of public lectures, website features and exhibitions.

Interdisciplinary antecedents

Our antecedents in interdisciplinary TEL, which had been the focus of our individual research activities before our current programme, included earlier work in developing and supporting creative learning communities and trying to devise relevant methodologies for investigating and under-standing their dynamics. We have both had long-term interests in integrating technologies with learning and helping participants to find their own voices in a range of disciplinary contexts.

One of us (Sclater) investigated extensively how informal and globally distributed learning communities, whose disciplinary focus was art and design higher education, could work together within networked environments to develop their creative practice both individually and collectively (Sclater et al., 1997, Sclater, 2007). This research was broadly concerned with exploring and developing 'new' pedagogical models to support distributed studio-based education. It focused on developing ways of supporting learners to participate in a distributed model of studio education and considered how such a community could be developed and nurtured over time. It was based on co-operative and collaborative pedagogical models that were implemented to support and drive activity and develop a learning community (Reynolds et al., 2004; Sclater and Bolander, 2004). The research explored the impact that these participative forms of learning had on the development and realisation of participants' creative visual thinking processes and outcomes. The work evidenced how 'shared practices' (in the initial work these were co-developed visual montages) could help to bind a distributed community. The research provided evidence-based case studies that pointed to ways in which studio-based education in art and design higher education might be conceived in the future.

In terms of theory, the research tried to integrate key explanatory features of several overlapping theoretical frameworks to focus the investigation and interpret the findings. The main purpose of this was to develop a detailed and multi-layered understanding of the nature of the learning that occurred within networked environments, and how it occurred, in participant groups working together to create their joint visual artefacts. The theoretical frameworks included social constructivism, situated learning, socio-cultural theory and motivational theory. This multi-theory approach was later developed into a theoretical strategy to help new researchers understand the importance of theory (Sclater, 2012).

The main findings of this far-reaching work included extensive evidence that visual and creative processes and effective learning can occur in groups of geographically remote individuals working collaboratively through the Internet, using an educational (textual and image-based) design that structures learning activity and collaboration. This had major implications for the development of pedagogical designs for art and design education, an area where there were almost no reports of this kind of work at the time. The work attempted to articulate some of the details of these new designs, based upon empirical evidence drawn from research in real educational settings. It was also aided by a comparison of findings from the case studies. These understandings became the basis of an interdisciplinary contribution to the Inter-Life project using voice/artefacts from art and design.

In a parallel series of methodological investigations, spanning 10 years, one of the authors (Lally) carried out a programme of research to develop and refine techniques for understanding how students and tutors work, learn and interact in computer-supported collaborative learning (CSCL) environments (we also used the term 'networked learning' as equivalent to CSCL in these studies). These spaces were the precursors of the more modern three-dimensional environments, such as Second Life™, in which Inter-Life was subsequently developed (see section entitled 'A TEL interdisciplinary project – Inter-Life' later on in the article). The investigations were largely undertaken in asynchronous text-based systems, including Blackboard, Lotus Notes and WebCT. Much of the work was conducted with adult learners, who were globally distributed and engaged in forms of collaborative continuing professional development. In the first stage of this work we tried to develop and implement forms of textual analysis using coding schemas that would help us understand the types of cognition and metacognition that were taking place in group discussions and interactions (De Laat and Lally, 2003; Lally and De Laat, 2002). This kind of approach has subsequently become quite popular. We also looked at the role that theory plays in this kind of analysis, which helped us to focus on analysing activity and defining 'activity units'. We soon realised that the value of coding textual utterances to understand learning could be enhanced by looking at the volumes of message flow and the 'centrality' of some participants in the discussions. As a result, we adapted techniques of social network analysis (SNA) for use with our experimental learning environments analysis (De Laat et al., 2007a). As patterns of activity and the particularity of some participant behaviour emerged, we investigated the problems of identifying the emergence of particular roles (De Laat and Lally, 2004a). We also looked at the characteristics of the teacher's role using content analysis and SNA (De Laat et al., 2007b). This was complemented by taking a similar approach to analysing student activity (De Laat et al., 2006) and the nature of group interaction more generally (De Laat and Lally, 2005). These investigations effectively provided us with a baseline of techniques that painted a detailed picture of individual and group behaviours in CSCL in a range of teaching and learning contexts. We then looked at some more advanced approaches to textual analysis using pattern languages (Goodyear et al., 2006). We tried to understand how theory was being used by others in this kind of work, and argue for its importance (De Laat et al., 2006). As an important parallel track of investigations, we also looked at some of the key issues and challenges facing CSCL. These included analysing real-world online creativity (De Laat and Lally, 2004b) and identifying some of the key CSCL research questions (Carr et al., 2006). In addition, we looked at professional development for CSCL tutors (Lally and McConnell, 2005), and at the ethical issues of TEL (Lally et al., 2010, 2012).

TEL and 'crisis'

There has been much recent discussion in the international TEL research community about 'crisis'. It may be that crisis is now the endemic status of the 'globalised' education system, and this is a

relevant contextual factor. In Section 2 we also referred to the 'disciplinary crisis' that has been going on in the social sciences for an extended period, and probably in education as well, as far back as the 1970s. However, these wider factors are too extensive to analyse further here. However, because TEL is an applied area of activity covering both research and practice, it is inevitably influenced by, as well as exerting influence on education systems and wider dominant research paradigms; these relationships may well be 'asymmetric' in the directions of these influences. Nevertheless, there are palpably signs of crises in the TEL literature.

In 2012, we were approached by our collaborator John Traxler to participate in a workshop that he was involved in organising about the 'crisis' in TEL. John had been working as part of a group called Education for the Crisis (2012), whose members held a workshop in Leicester (Traxler, 2012) to examine the wider crisis in education. One of the directions in which this led was to the 2013 international Alpine Rendezvous (ARV) workshop in Villard de Lans (Lally and Traxler, 2016: 935) and then, in 2016, it also led to our special issue on interactive learning environments (ILE), which reflected on the ARV workshop, elaborated on the TEL crisis and explored some 'solutions' and further analysis (Lally and Traxler, 2016; Traxler and Lally, 2016). As Beetham et al. (2016a) remind us, our ARV workshop aimed to explore

> the role that digital technologies in education have played and continue to play in the emergence of various discontinuous ruptures and crises [and] to understand the role of TEL in generating and sustaining crisis and disruption, as well as in ameliorating some of the effects and enabling a principled response.

As we explained extensively in the 2016 introduction to the special issue on ILE, the TEL research community has had very considerable success in the previous two decades in implementing the prevalent models, practices and theories of education. This has been achieved in an extraordinarily wide range of disciplines and institutional frameworks within many contexts and settings. Although this gave TEL a 'presence' in the existing discourses of higher education, industry and government, it also left TEL beholden, and almost inextricably linked to models of education that were predicated on expansion and massification. All of this was occurring amid increasing turbulence in wider social contexts, including the ongoing globalisation and corporatisation of learning, and took place against the backdrop of economic and resource crises, long-term increases in economic inequality, European youth unemployment, the polarisation of employment and a very widespread decline in growth. These trends have been pervasive, and also include sovereign debt defaults and banking failures, mineral and energy constraints, and environmental and demographic crises. Climate change, in particular, has had major implications, for example, with regard to declining land viability and related migration patterns (Klein, 2016). Furthermore, there are the increasingly urgent refugee rights issues linked to military occupations and population growth, and this has implications for agriculture, infrastructure and transport.

As we are increasingly aware, there is also a continuation of these wide-ranging processes into what can now be seen as a series of 'crises of accountability' (Giroux, 2017). This includes the failure of representative democracy systems and of global markets and incorporates a reliance on non-human large-scale systems in finance (Hudson, 2017). Phenomena such as computerised share-dealing, new private sector actors in public services, the growth of new participatory movements and the rise of unelected minorities are challenging the legitimacy of the nation-state and its institutions.

In terms of the Internet itself, the increasing concentration and centralisation of Internet dis-course in the 'walled gardens' of social networks, related to the proliferation and complexity of digital divides, poses further threats to democracy (Lanchester, 2017). Alongside this, the dependency of our educational institutions on computer systems for research, teaching, study and

knowledge transfer is increasingly prevalent and increasingly documented and analysed (Perrotta and Williamson, 2016; Williamson, 2014, 2017a; 2017b). The nexus of these developments was described by the Education for the Crisis group as the 'dehumanisation crisis', resulting in the production of fear between people, the replacement of human flourishing with consumption, the replacement of the idea of the person with the idea of the system, the replacement of human contact with mediated exchange and the commodification of the person, education (Williamson, 2016) and the arts.

What has become much clearer given the foregoing, we have argued, is that the globalisation of education and economies, and their contingent crises, requires novel thinking within the TEL research community and also more widely within international educational constituencies if we are to respond to these challenges. We have argued that the world is now 'increasingly characterised by disturbances and discontinuities that threaten dominant notions of stability, progress and growth' (Lally and Traxler, 2016, p. 936). These represent the grand challenges to the TEL research com-munity, challenges that involve staying relevant, responsive, rigorous and 'useful', as well as critical and watchful. This community must engage in '*futures thinking*' as a process to develop TEL in relation to a wide range of pressing concerns including,

> TEL and marginal communities; the political economy of technology in higher education and responses to the crisis of capitalism; the role of openness as a driver for innovation, equity and access; digital literacies and their capacity to shift TEL beyond skills and employability in an increasingly turbulent future; connectedness and mobility as seemingly the defining characteristics of our societies; the role and responsibility of research and of higher education as these crises unfold; the complicity or ambiguity of TEL in their development.
>
> (Traxler, 2012)

Clearly, the existing TEL 'ecosystem' is no longer sustainable; there are multiple reasons to argue that TEL needs to reconfigure its research questions in order to 'support, stimulate, challenge and provoke its host – the higher education sector' (Lally and Traxler, 2016, p. 936).

For us, the 2013 ARV workshop led to the Networked Learning Symposium (Beetham et. al., 2016a). Here, Helen Beetham's initiative helped us, as a group of TEL researcher-practitioners, to take a collective focus on the project of examining the implications of a globalised education sys-tem for social justice and collective wellbeing. The symposium was based on the premise that the 'TEL project' (see section entitled 'A TEL interdisciplinary project – Inter-Life' later on in the article) has 'coincided with the growth of technicist, managerial and commercialised discourses of education' (Noble, 2012) and that these have weakened commitments to education as an emancipatory project and a democratic right. The symposium focused on some of the key issues arising from this nexus of challenges. These included the implications of digitisation for future employability (Beetham, 2016), a fundamental critique of learning analytics by Perrotta (2016), an analysis of inequality issues and massive open online course (MOOC) development in higher education, citing evidence from South Africa (Czerniewicz, 2016) and an exploration of the role that theory might play in the development of forms of 'intellectual self-defence' (Sclater and Lally, 2016b). For now, we will let Beetham's introduction to the symposium supply the final words encapsulating these concerns:

> Even in conventional settings we see an ever-greater involvement of data systems to measure 'learning gains', to micro-manage features of the curriculum, and to place student learning behaviour under surveillance. In a global education system which functions as a market – in both knowledge and students

> – transferability, interoperability and reproducibility of learning outcomes are important. So not only is it becoming technically feasible, there are also financial and competitive pressures for rich learning experiences to be rendered into 'learning data' or closely specified 'competences' that function as an international currency, floating free from the lived experience of learners or the cultural life of institutions. The price is the systematic devaluation of those aspects of the educational experience that cannot be rendered as data. And it may be precisely these aspects – such as identity work, building repertoire and resilience, recruiting cultural resources, one-to-one personal and peer support, developing a critical stance towards knowledge and practice – that disadvantaged learners need most.
>
> (Beetham et al., 2016b: 28)

A TEL interdisciplinary project – Inter-Life

The Inter-Life research project was a three–year, ESRC/EPSRC-funded interdisciplinary project (2008–2011), followed by an additional two years of intensive research writing that involved 10 interdisciplinary academic researchers drawn from across the universities of Glasgow, Stirling, Heriot-Watt (previously Edge Hill University) and Sheffield. The project investigated the use of virtual worlds and creative practices drawn from the domain of art and design, such as photography, digital storytelling and film making, for supporting transition skills development among three separate communities of young people. Two of the communities were a group of young people aged 13–17+ , some of whom were also in local authority care, and a group of young people aged 18+ (Lally and Sclater, 2012: 499).

The project also involved significant interdisciplinary research contributions from the domains of computing science, general education, social sciences and psychology. The Inter-Life project contained a blend of technological and educational research aims. This required the research team to develop mutual understandings of each member's disciplinary area and their specific contribution to the project and how these areas could be most effectively developed and realised to support the creative, interdisciplinary synergy that we would later develop as a research team. In total, the project produced many interdisciplinary journal articles (Devlin et al., 2013, 2015; Lally and Sclater, 2012, 2013; Lally et al., 2012; Sclater and Lally, 2013, 2014, 2016c) arising directly from the empirical data. As the project was complex and multifaceted, each article focused on a blend of themes. A short narrative of the foci of each of the articles is woven into the following high-level project overview summary. This also includes our own personal reflections on the interdisciplinary nature of this work.

Inter-Life project aims: Working alongside young people in technological settings

The educational and technological aims of the project were inextricably linked because the realisation of our educational aims was, to a large extent, dependent upon the possibilities afforded by the technological development aims determined at the outset. Of course, the usability of the technology was dependent upon participant feedback and, therefore, the research was driven by this symbiotic relationship that was also iterative. The aim of the Inter-Life project was to explore *how* engagement in *creative practices* within novel, three-dimensional immersive environments – commonly known as open-ended 'virtual words' – could be used to support the development and acquisition of *life transition skills* among young people aged 13–17+ and 18+. Virtual worlds are 'persistent avatar-based social spaces that provide players or participants with the ability to engage in long term coordinated conjoined action' (Thomas and Brown, 2009: 37). Their use in this con-text (see Sclater and Lally, 2014: 3) was to help young people understand and navigate the social

and emotional challenges of real-world life events (Lally and Sclater, 2012: 480), to actively engage them in developing their understanding of citizenship and social justice (Sclater and Lally 2013: 332) and to encourage the young people to articulate their own personal and collective goals and motivations for their present and future lives (Sclater and Lally, 2014). The Inter-Life project was, therefore, concerned with creating a virtual space in which participants could explore important issues in their lives, alongside the opportunity to develop the emotional and cognitive assets needed to assist them during key transition events in the real world (Lally and Sclater, 2012: 498). In this way, the Inter-Life project aimed to develop a safe, flexible environment for risk-taking and conflict resolution and for the development of a range of life skills that could be used by the young people in future life transitions (Lally and Sclater, 2013: 320).

Infrastructure: Inter-Life islands I and II

The Inter-Life project set up two secure islands in Second Life™ – a novel, technology-enhanced, three-dimensional, immersive environment run by the privately owned, commercial Internet company Linden Lab. Second Life™ is a 'virtual world' that is both avatar based and networked, and that also allows users to customise the infrastructures and spaces. It includes artefacts and tools to support activity. The project created and co-designed two island environments in consultation with user participants. We called these islands Inter-Life Island 1 (ILI-1), where young people aged 18+ could work on school–university and within-university transitions, and Inter-Life Island 2 (ILI-2), where young people under the age of 18 (13–17+) could work on creative activities and skills development linked to the challenges of real-world transitions (Lally and Sclater, 2012: 481). Virtual worlds, such as Second Life™, in which these two islands were constructed, offer many possibilities for creative expression through engagement in creative practices (Doyle, 2008). Therefore, we conceived the Inter-Life islands as a 'virtual youth centre' – *an integrated intercultural context* (Lally and Sclater, 2012: 483) – within a creative, contemporary virtual world, in which young people could set their own agendas within the ethical parameters of the project and in discussion with the research team (Lally and Sclater, 2013: 330), and participate in authentic learning opportunities (Devlin et al., 2015: 405). The Inter-Life project, therefore, offered participants a highly visual space that included a blend of web-based and mobile technologies and a suite of 'transition tools' (Lally and Sclater, 2012: 483–484; 2013: 320), which, taken together, provided creative affordances such as 'co-presence', 'immersion' and 'embodiment' (Devlin et al., 2015: 405). Inter-Life, to some extent, resembled the real world, but it offered users particularly novel and intriguing features such as the ability to customise or radically change their avatar appearance, fly, walk under water or reconfigure the space effortlessly (Lally and Sclater, 2012: 334). From the very outset it encouraged participants to engage in the co-design of Inter-Life's spaces and environments, tools and activities. The 'transition tools' referred to earlier drew extensively on creative practices in art and design (Lally and Sclater, 2013: 320) and were conceptualised and implemented by the research team to gather together innovative ways of working and communicating with the young people to develop new skill sets to support their understanding of transitions in various contexts (Lally and Sclater, 2012: 284; 2013: 320).

Transitions

A key theme of this work has been our focus on 'transitions' and providing opportunities to support young people to develop the required skills to manage transition within a virtual world framed within the discourse of career guidance and counselling (Lally and Sclater, 2013). Many young people are now required to navigate many multifaceted events that arise in their personal and

educational lives. In the Inter-Life project, the young people with whom we worked discussed and addressed issues such as: bullying and drug taking; moving from one school to another; managing transitions from school to university (or between years in university); handling relationships within the family; coping with bereavement; exploring future career choices and personal strengths; and the sharing of interests, hobbies and life situations. Transitions can, therefore, involve social, cognitive and emotional change, including changes within the family, as well as dealing with new expectations and requirements of educational and work placements. It is now recognised that transition can occur at any time during a person's life course, and that the journey from adolescence into adulthood is no longer conceived as a linear process. To handle change, uncertainty, complexity and risk, young people need to acquire a wide range of competencies throughout their life course (Ahier and Moore 1999, cited in Devlin, 2015: 407; Lally and Sclater, 2012: 483). We have argued that many of the contexts in which young people find themselves are so multifarious that the cognitive and emotional demands require much more support and different resources that transcend the traditional boundaries of school and home (Lally and Sclater, 2012: 483).

Key areas of investigation

As a research team, we had a number of key educational questions to investigate, driven by our literature review. The full suite of educational research questions is outlined in Lally and Sclater (2012, 2013). Participants' engagement in a range of creative practices (creative practices being conceived as one of the 'transition tools') within this virtual world provided the principal vehicle for understanding the dialogue, emotions and multiple perspectives that can be expressed in such a space. This created a rich context for analysis. A key question we wished to address was participants' use of the 'transition tools' – *how* they engaged in the creative practice activities and *what meaning* they made of this engagement. Related to this we wanted to probe the extent to which the young people were able to develop and acquire transition skills and how these 'transferred' into real life (Lally and Sclater, 2012: 486). For example, how do risk, conflict and goal setting under-taken in the Inter-Life setting correlate with real-world experience and behaviour? (Lally and Sclater, 2012: 486, 2013). We were also interested in understanding how young people's identities changed and transformed over the course of this project. How did new insights develop among participants, enabling them to reconfigure the way they viewed the world while engaged in authentic activity? This helped us to understand the impact that engagement in creative practices had on participants and also how to scaffold creative activity in a virtual world to support community development and cohesion (Devlin et al., 2013; Sclater and Lally, 2013). We were also interested in understanding how participants *experienced* Inter-Life as a whole – how participants used and inhabited the space and how they interacted with the environment and with each other and not only via the planned workshops but through their individual forays into the environment outside of planned workshop time.

Project participants

The project had three separate participant groups, including self-selecting volunteers working with the research team: a group of pupils and their teacher in a secondary school in Trinidad (aged 13– 17+); a small group of young people living in care in Glasgow and Sheffield (aged 13–17+) and a group of first-year university students studying at the University of Glasgow (aged 18+). The Trinidad research community consisted of young people from a fee-paying school in Trinidad, and this group was co-ordinated by a teacher at the school who also participated in the project. Members of this community were living with their own families and tended to have access to Internet

connectivity and software/hardware resources in their own homes. The Glasgow/Sheffield group was made up of around 10 young people, most of whom were in local authority care. The group of young people aged 18+ consisted of 35 first-year students at the University of Glasgow (Devlin et al., 2013).

Ethics and participation

The team-developed ethical approval was obtained through the University of Glasgow and all participants in this research were volunteers who gave their permission for data use before they joined the project. As the aim was to work alongside young people, some of whom were in local authority care, the research team developed a strong partnership with a range of professionals in social services and children's services. The research team were dedicated to the safety and security of the research participants and their carers and, as such, several important safety measures were instigated. For example, only the young people aged 13–17 could access ILI-2, and all adults working on the Inter-Life project (research team and guardians or carers of the young people) held enhanced Disclosure Scotland (or security) checks (Devlin et al., 2015: 409). The research team developed tailored registration applications programme interface (Reg. API) web registration systems that securely logged new account details as they were created for participants by the researchers (Magill et al., 2009). Additionally, the team developed a 'recording grid' that automatically recorded the avatar three-dimensional positional co-ordinates and in-world text communications in a time-stamped manner for reasons of security, and provided the project with a record of all interactions. ILI-2 was not accessible to the public, but only to those young people who had agreed to participate and had been registered by the research team (Devlin et al., 2015: 408).

Creative practice research

The visual arts programme of the Inter-Life project was led by the only visual arts educator, (Sclater) in collaboration with associates. The creative practices research of the Inter-Life project is discussed in detail elsewhere (Lally and Sclater, 2012, 2013; Sclater and Lally, 2013, 2014). The project's principal driver of activity and vehicle for undertaking these personal and collective explorations was the young people's engagement in a range of creative practice activities drawn from the domain of art and design, including photography, film making, digital storytelling and fashion. Creative practices were one of four sets of 'transition tools' that were used by the young people (Lally and Sclater, 2012: 484). Participants' active engagement in creative practices helped to foster and support meaningful dialogue among the young people and the members of the research team and this was central to the cultivation of a 'virtual research community' among project participants. The thinking underpinning the use of creative practices was to give young people a vehicle for the expression of their feelings, ideas and emotions (Lally and Sclater, 2013: 320). It was intended that, in this way, the expression could be uniquely theirs, and could be shared with others within and outside of the group. In harnessing a wide range of non-verbal modes of expression, creative practices helped to make these expressions more inclusive (Lally and Sclater, 2013: 321).

Reflections on interdisciplinarity in Inter-Life

The early days of our project were taken up with wide-ranging conversations to fully comprehend and coherently articulate the research aims and ambitions that we had formulated through the project proposal. At first, these conversations involved much in-depth explorations of the

philosophical, educational and technological rationales underpinning the project vision, including many important ethical considerations that the project raised. At first, paradigm differences seemed to be insurmountable as team members each clung to the security of their own expertise, within the realm of our own disciplinary experience. At the same time, each person strove to transcend these boundaries to understand each other's expertise and to relate this to personal knowledge. Frequently, we felt that we were each locked in a parallel universe, with our own disciplinary languages seeming to lack sufficient power to communicate.

There is an irony here in that on one hand we appeared to have a collective interdisciplinary coherence in terms of what was written on the proposal, but on the other there was a distinct feeling of uneasiness in the sense of us not 'being on the same page' when we came together as a team. Such a feeling, of course, was understandable given that we were coming together as a group for the first time. We had not previously worked together in this way, and not all members of the team knew each other. However, as we became more actively engaged through our lived experience with our project, the participants and their own research agendas, we began to jointly develop a much deeper and more holistic understanding of our thinking as the project unfolded in real time. This included understanding the technologies that enabled these interactions, and our engagement with the various research literatures to which we were referring.

The significance of engaging in the real world to understand what was practically feasible, while continually navigating the contingent nature of working with human participants and their interactions with the technologies, cannot be underestimated. Actively setting time aside to reflect as a team on a regular basis and our enthusiastic engagement with the research writing process were key elements in the development and crafting of our interdisciplinary narrative. This co-construction of interdisciplinary knowledge was developed and redeveloped over time in an iterative way. It took patience and perseverance, particularly in the face of the enormous challenges in working with the demographic we had selected to research – young people who were also living in care – but also in relation to the technological ambition we had set for the project. It is too easy, in hindsight, to reflect on the process as something that occurred in a smooth fashion. Perhaps that's the version of the narrative we'd prefer to remember as a team; however, this was certainly not the case.

Like many research projects of an interdisciplinary nature, the process went through consider-able peaks and troughs as we grappled with the reality of the technological implementations, including the reality of working alongside the young people who also held their own agendas. A practical challenge that we encountered was being able to equip the young people living in care with sufficient computing technology (hardware and software) so that they could engage with the project on a regular basis and over time. At the start of the project, the research team spent many months liaising with care home managers and social workers in connection with installing computers in the young people's homes. We intended to provide dedicated as well as secure access to Inter-Life Island. However, for a variety of reasons related to the management of the care homes, the young people's access to computers was, unfortunately, curtailed. This was disheartening, given the significant effort involved in agreeing to the installation of the computing equipment alongside a programme of regular weekly visits by the research team to the local authority homes where the young people lived. Therefore, instead of the research team going out to visit the young people, we agreed to hold the workshops at the University of Glasgow on a weekly basis instead, with the local authority agreeing to organise transport to the university. At first, our project seemed to be beset with practical, ethical, philosophical and technological challenges. The challenges we experienced were due to the scope and ambition of the interdisciplinary project, including the significant organisational and technological overheads that were required.

Theories and TEL

In our account so far, we have pointed towards interdisciplinarity, and its 'interweaving' with disciplinary research (using examples from our own earlier research histories and interdisciplinary collaborations) as an important means of reimagining the present and future of TEL research and teaching activity. In the previous section, we gave an account of the Inter-Life project to illustrate a TEL project arising from a major interdisciplinary collaboration, which led to theoretical and methodological developments, and tools, as well as new understandings of informal learning, and which provided examples from one of the contributing disciplines. However, we argue that the role of theory should not be overlooked, because it is another important aspect of the process of reimagination, both for practice and research in TEL. Theory is one of Nissani's interdisciplinary 'domains' (alongside knowledge, cultural innovations [e.g. research] and education). Our focus here is on the questions: What do we want theory to do in TEL research? Can it be part of our project of reimagination?

In our search for answers to these questions, we looked back to the 1990s, particularly to the work of a small number of researchers who have focused significantly on this domain. Stephen Ball (1995) was one of them. Ball expressed deep concerns about theory in his own discipline. He observed that management theory was playing a diminishing role in school effectiveness research, and explored questions similar to our own about the role(s) that theory should play in his areas of study. He elucidated an argument which, in summary, makes the important point that theory is (in effect) a form of self-defence for researchers. Without theory, he argued, educators risk becoming technicians of policy implementation. Theory, he continued, is one of the ways in which research-ers can claim and reclaim educational research. Furthermore, he went on to suggest that it was likely one of the ways in which researchers could stave off the charge of acting as 'technicians' in the educational world. Ball argued that theory could help by supporting researchers to 'think otherwise' (1995: 266, 268), and 'be disruptive' (1995: 266). He also argued that it could provide a language for challenge, act as a stimulus for rigour and irony and help to open up spaces for critical thought and reflection – a key part of our project of reimagination. Part of the problem, as research-active academics know, is that using theory can itself be fraught with problems. Ball pointed to the sheer complexity, difficulty, contingency and contradiction inherent in theory use and development, arguing that this reflects the nature of reality. He argued, from a standpoint that related his position to the wider sociology of education, that theory was, nevertheless, a powerful tool in educational studies. We note that in relation to the 'dual invisibilities' of TEL, to which we referred earlier, TEL is still not yet very well connected to the wider sociology of education. This view is more recently supported by Selwyn, in his seminal papers on TEL and sociological theory. He insists that such an approach might seek to 'identify, highlight and overcome the many contradictions and conflicts that surround the use of technology in educational settings', arguing that current inequalities and hegemonies need to be countered (Selwyn, 2010; 2012).

We also looked further back, to the work of Lawrence Stenhouse (1983), who had argued that educational research is a process that involves the joint development of educational praxis (practice informed by reflection and/or theory) and theory, and that they operate by interacting (Stenhouse, 1983). Stenhouse was concerned about articulating modes of research inquiry appropriate to education, as well as to the role of practitioners in the research process. We have previously explored this idea of an ongoing iterative process in research, that between theory and practice/praxis (De Laat and Lally, 2003; De Laat et al., 2006; Goodyear et al., 2006). In this way, we can understand how theory can be created, developed and maintained through a process of constant iteration with evidence from practice. Halverson (2002) has further clarified some of the more pragmatic roles that theory can play in research. Halverson's roles include being descriptive, that is, allowing researchers

to focus through the theoretical lens, and provide a language with which to speak about their work. She points out that theory can also be inferential, suggesting directions for investigation and, hence, guiding inquiry. Theory can also be rhetorical, providing us with the coherence, language and confidence to discuss matters in our research communities. Finally, Halverson argued, theory can help us to apply our findings to the real world and assist us with practical issues, such as designs arising from our work. When combined with the iterative process between theory and praxis/practice, these roles provide a useful framework for employing theory in TEL research and teaching that enhances its usability in the face of Ball's real-life challenges.

In our own work, this historical approach brought us to third-generation activity theory or, more accurately, cultural–historical activity theory (CHAT) (Engeström, 2009; Engeström and Glaveanu, 2012; Roth, 2004) as a highly comprehensive theoretical approach that has extensive applicability in TEL settings. It was originally conceived by Vygotsky and Leont'ev (Roth, 2004). CHAT takes human 'activity systems' as the unit of analysis. Roth and Lee (2007) have suggested that CHAT can overcome a 'range of troublesome dualisms in education: individual versus collective; … subject versus object … theory versus praxis'. They point out that it is not a 'quick fix'. It is, however, a historically and culturally robust theory of human activity, of sufficient power, we argue, to aid researchers in resisting political and economic. It is aimed at developing critical understandings of TEL, encouraging researchers in the project of reimagining the future of TEL academic work and learning.

Discussion: Interdisciplinary benefits and possibilities

Two persistent experiences in our work as researchers and TEL teachers (jointly and separately) and in our project of reimagining these activities have been of: (i) the power of interdisciplinarity as a rich source of ideas; and (ii) of the value of theory to our understanding of the complexity of TEL. Theory (particularly CHAT) has helped us to re-ground our thinking about TEL in terms of the primacy of human activity and interactions driven by human motivations and goals (see particularly Sclater and Lally, 2014 for a detailed account). CHAT includes human emotions, developing projects, and the historical and cultural contexts of activity. In the present article, we have mainly focused on setting out a case for interdisciplinarity in TEL. This has been partly based on our personal experiences and reflections. We have sought to illustrate this with examples from our own work. We have also shared our interdisciplinary antecedents to give a picture of how we have woven together a variety of disciplinary elements of our work with interdisciplinary activities. For us, interdisciplinarity has become increasingly central to the intellectual endeavour of our TEL projects, to our way of working in TEL pedagogy and research and, increasingly, in reimagining new projects, such as the pedagogy of a socio-ecological sustainability network. To paraphrase, this is part of our response to the grand challenges of the TEL research community – to stay relevant, responsive, rigorous and 'useful', as well as critical and watchful. We have argued that the community must engage in '*futures thinking*' (reimagination) to develop TEL in relation to a wider range of pressing concerns.

We have attempted to show how our research, including recent research arising out of the InterLife project, has made pedagogical, methodological and theoretical contributions to the field of art and design education, for example, the continuing development of advanced research methodologies (e.g. avatar-automated mapping [tracking], discourse analysis techniques and critical event recall) involving the use of visual research methods (photovoice, photography, film making, rich pictures, storytelling, interactive story boarding) to investigate and sustain learning communities (formal and informal) in virtual environments. These developments have been essential to the design of virtual environments for actively engaging groups and communities in art- and

design-based activities to support and enhance psychological wellbeing, social development and educational transitions. This work also led to researching and elucidating the ethical aspects of engaging individuals, groups and communities in creative exploration and expression using advanced technologies in virtual environments. In addition, it has led to investigating and developing innovative pedagogical approaches (e.g. through collaborative working and participatory research online) to social justice education through technology that draws on the field of art and design education as the principal vehicle for exploration. Theoretical innovation has been pursued using activity theory as a research lens for investigating the relationship between learning, creativity and collaboration in virtual environments with art and design education.

The reimagined 'value' and significance of disciplinary areas can be expressed through interdisciplinary collaborations. For example, one of the main challenges currently faced by art and design education as a discipline has been the need to assert and develop its significant potential for creative contributions to a wide range of pedagogical and research activities across the arts, humanities and social sciences, as well as in STEM subjects. It is through the development of these interdisciplinary linkages that art and design education will flourish and grow, bringing the novel work of these collaborations back to host institutions for further engagement, critical evaluation and the enrichment of curricula and research within the creative disciplines. These interdisciplinary link-ages and the collaborations they support have enabled art and design education to engage in key research and teaching domains that employ visual and creative practices. For example, interdisciplinary TEL work by one of the authors (Sclater) that is grounded in the domain of art and design has addressed multiple under-researched aspects of teaching and learning, including informal learning, vocational education, social justice education and sustainability education.

Our interdisciplinary approach has also impacted on education itself. For example, the Inter-Life project taught us a great deal about how to build and support co-designed learning spaces. We used these to create learning communities with young people in which they were supported to develop their own learning and research agendas. This space and these activities were highly informal, outside of the formal curriculum and outside of institutional settings. The work was supported with a blend of technologies that included Twitter, mobile phones, and interactive visualisation boards set within Inter-Life. These developments arose from interdisciplinary collaborations between education, art and design and computer science. The result was an understanding of informal learning that has many implications for the reimagination of forms of higher education and school education. The application of CHAT to the understanding and analysis of these contexts revealed the motivational power of 'runaway objects' (Engeström, 2009) and the value of project-oriented collaborative working with young people in learning settings. One of the challenges in virtual learning spaces is to create a sense of presence and engagement among participants and to maintain this during extended periods of learning activity. One of the ways in which we attempted to do this, working as educators, was to collaborate with computer scientists to integrate instant chat and electronic voting systems (EVS) into the educational environment of Inter-Life. Part of the nature of this kind of interdisciplinary collaboration between researchers is that it can create a high demand in terms of intellectual and practical resources. It becomes obvious as to which supportive TEL innovations would be useful as an educational environment develops. Unfortunately, this does not necessarily make them easy to implement, as we found at several points during the Inter-Life project. Nevertheless, the idea of supporting group activity using EVS was further investigated and developed in other contexts (Bowskill, 2013; Bowskill and Lally, 2018). The concept of creating and using virtual worlds to support informal learning was further developed from this work into an investigation of their potential for small- to medium-sized enterprises (SMEs), where the resources for staff development in any one situation may be minimal. Again, this work has much potential for further development in SMEs (Jewitt, 2018).

The project of engaging with the reimagining of higher education through the lens of TEL, illuminated by interdisciplinary collaborations, especially between art and design, and education, but also, more briefly, including computer science – for ourselves and our students – has been our main concern in this article. We have used personal reflections to share our experiences of weaving our disciplinary backgrounds with our interdisciplinary projects to illustrate the power of this approach in the process of developing new TEL research and new pedagogies. We have also tried to provide a pragmatic and usable account of interdisciplinarity by drawing extensively on the work of Nissani. This has been augmented with a summary account of our highly interdisciplinary Inter-Life project to illustrate our interdisciplinary working. Our own backgrounds in art and design, and education have been formative in this work. We also argue that the value of theory should not be overlooked. TEL urgently needs more theoretical and sociological work to help ground it more firmly in ways that will help teachers and students to reimagine and create their own educational futures more profoundly, clearly and justly.

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Vic Lally is a Professor of Education in the School of Education at the University of Glasgow, UK. He was Director of the Interdisciplinary Learning, Education, Technologies and Society Research Group (ILETS) and is currently an Associate Director of the Centre of Computer Science Education, and a core member of Centre of Research and Development in Adult and Lifelong Learning. Vic has researched and taught in many educational settings, including the recently completed Inter-Life Project for the UK Research Councils (EPSRC and ESRC). His main interests are in human learning: its `design', philosophy and ethics, as well as the cultural and political contexts of learning. He is particularly interested in collaborative learning as a way of supporting human creativity and development.