An investigation of technology mediation in interdisciplinary research within Higher Education

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Abstract

There has been a growing awareness of interdisciplinary collaboration as a means of addressing new challenges within academic research, and digital technology has been a core underlying support in these endeavours (Scanlon et al., 2013, p.49; Haythornthwaite et al., 2003, p.144). 'Digital technologies will be a core aspect of interaction and cooperation between different fields of expertise' (Costa, 2011, p.84). This paper investigates the process of technology-mediated knowledge co-production in interdisciplinary research in Higher Education, and explores how researchers from different disciplines appropriate technology to break down disciplinary boundaries. Through the presentation of findings from a collective case study of two interdisciplinary research projects based at the University of Oxford - the Ashmolean Latin Inscriptions Project (AshLi) and Poetry Visualisation: Imagery Lens for Visualising Text Corpora (PVis) - this paper aims to challenge conventional approaches to investigating the use of technology in interdisciplinary scholarship, responding to the paucity of research at the intersection of interdisciplinarity, collaborative research and technology in academia.

Findings from interviews with academic researchers, and a visual analysis of project artefacts, elucidate a *mutually shaping* relationship between innovative research technologies and new interdisciplinary research practices. Technology can be constructed through the integration of disciplinary perspectives. Researchers from different disciplines both adopt and adapt technologies, and through these processes, disciplinary boundaries are broken down, and knowledge is co-created. This iterative process of mutual shaping assumes different nuances according to the disciplinary 'make-up' of a project, the technologies involved, and the ways in which the researchers appropriate technologies according to their disciplinary backgrounds.

Using the social construction of technology (SCOT) as a theoretical framework illuminates researchers' diverse perceptions of technologies and interdisciplinary practices, and highlights the importance of interpretation in the use of technology within these contexts. This paper contributes to the area of networked learning by highlighting that collaboration around research technologies has not been explored very much in the field, nor has the potential for building on other concepts from the area of science and technology studies (STS) such as Actor-Network Theory (Clough et al., 2010; Adams and Thompson, 2014). In this way, the findings hold broad implications for substantive promotion of a more nuanced view of modern interdisciplinary practices.

Keywords

Interdisciplinary research, technology, collaboration, digital scholarship

Introduction

With the radical shift in how digital technology affects information dissemination in the modern world (Castells, 2004), technologies have been positioned as 'powerful mediating artefacts' (Scanlon et al., 2013, p.49). They are recognised as fundamentally transforming the way scholarly research is conducted across disciplines (Dutton and Jeffreys, 2010; Meyer and Schroeder, 2015). Berry (2012, p.1) acknowledges that 'across the university the way in which we pursue research is changing, and digital technology is playing a significant part in that

ISBN 978-1-86220-324-2

change… research is increasingly being mediated through digital technology'. However, there is a serious gap in the literature in understanding the *precise role* technology plays in mediating interdisciplinary research practice. This paper delineates between 'research technologies' used as tools for research (Shinn, 2005), and underlying Information and Communications Technologies (ICTs) used for collaborative, organisational and orchestration purposes. This delineation is also helpful in illuminating the fact that the majority of the research in the area of collaborative digital scholarship has focused upon the communication and orchestration aspects (Dutton et al., 2006; Derrick et al., 2011). Research in the area of research technologies is under-developed, and related literature with regards to interdisciplinary scholarship is even less so. Research technologies have a closer relationship with knowledge in how they are developed and appropriated (Shinn, 2005), and therefore research technologies are the focus of this paper. Furthermore, there are few studies related to the area of technology mediation within interdisciplinary practice that take any other position than that of technological determinism – the belief that technology shapes social practices (Oliver, 2005). They assume that technology provides 'a solution to the problem of collaboration' (Haythornthwaite et al., 2003, p.144), and in doing so, they 'fail to acknowledge the negotiation of practices and co-evolution of practices and technology that are involved' (Haythornthwaite et al., 2003, p.144). The majority of the research that has been carried out into the role of technology in supporting interdisciplinary practice relies on the technologically-deterministic concept of affordances (that is, the way in which technology supports certain actions), investigating how the 'affordances of different technologies influence mediation' (Clough et al., 2010, p.6). This conceptualisation of technology in most existing literature is a weakness in the bulk of current research into interdisciplinary practices, and it is this archaic approach which leads to outputs of limited value.

New approaches to technological mediation and interdisciplinarity

This paper takes a socially shaped approach (MacKenzie and Wajcman, 1985), moving away from the focus on technological affordances (Clough et al., 2010; Norman, 1989). There is a serious gap in our understanding of the role technology plays in the social shaping and re-orchestration of the interdisciplinary practices of researchers - with a few exceptions including Fry and Talja (2007) and Fry and Schroeder (2010). Indeed, Selwyn (2010, p.66) argues that 'more research is required that moves away from a means-end thinking about how best to harness the presumed inherent educational potential of digital technology, and instead focuses on the socially contested and socially shaped nature of technology'. Specifically, we use the social construction of technology (SCOT) (Bijker et al., 1987; Bijker, 1995) approach as it is a particularly suitable theoretical framework upon which to view the technological mediation of interdisciplinary research. Using the core idea of interpretative flexibility, that a technology can mean different things for different people – and therefore in the case of this paper, different disciplines - encourages an exploration of the potential shaping at work in a similar way to the study by Fry and Talja (2007, p.116). Thus, in this paper we advocate for developing new understandings of how interdisciplinary practice happens, and in particular how the social shaping of technology facilitates this process. This is not solely about facilitation, but about how technologies change interdisciplinary researchers' practices in fundamental ways. As noted by Miles and Rainbird (2014, p.2) 'while there has been some commentary on how the current emphasis on interdisciplinarity demands new practices… less attention has been given to what these… might [actually] look like'.

Methodology

Since this study is framed by a social shaping perspective, when choosing a methodological approach it was necessary that the interpretative flexibility of technological artefacts could be highlighted in line with this theoretical underpinning. Consequently, it was crucial to understand the perceptions of interdisciplinary researchers with regards to technology and to illuminate their practices in rich detail, and this therefore necessitated a qualitative approach to inquiry. It was also crucial to gain access to a diverse range of researchers across the disciplinary spectrum in order to construct more holistic models of interdisciplinary practice mediated by technology and to elucidate the interpretative flexibility of different technologies. The collective case study was chosen (Stake, 1994, p.237), within which the primary method of data collection was semi-structured, in-depth interviews, triangulated to a certain extent with visual artefact analysis (Bogdan and Biklen, 2007).

Two interdisciplinary research projects based at the University of Oxford, the Ashmolean Latin Inscriptions Project (AshLi) and Poetry Visualisation: Imagery Lens for Visualising Text Corpora (PVis), were selected as cases. The Ashmolean Latin Inscriptions Project aims to facilitate public access to certain inscriptions by creating an online corpus; the collaboration involves classicists, technologists and epigraphers. The Poetry Visualisation project is a retrospective case which aimed to create a new poetry visualisation tool; the team was

ISBN 978-1-86220-324-2

comprised of computer scientists, poets, and a linguist. Table 1 shows the most prevalent research technologies used within each case.

Table 1: Research technologies discussed in the paper

Project	Technology
AshLi	Reflectance Transformation Imaging (RTI) hardware and software - computational photographic method in which an object is lit and photographed from multiple directions
PVis	Poem Viewer - web-based tool for visualising poetry (Poem Viewer, 2012) http://www.ovii.org/PoemVis/
	Semantic Tagger (SemTag)
	Programming languages (HTML, CSS, JavasScript)

In-depth interviews were conducted with experienced interdisciplinary researchers across the two cases (N=7). Interview schedules explored interviewees' reflections on their specified research project, their thoughts regarding interdisciplinarity, as well as their uses of technological tools within the project, among other areas. Table 2 shows the disciplinary affiliations of participants in the study, and their unique interviewee codes. Interview transcripts were analysed through thematic coding in order to capture participants' voices in accordance with the theoretical framing. Themes were triangulated with notes from visual artefact analysis of the technologies themselves, and the two cases were then compared against each other. This study follows the ethical guidelines formulated by BERA, and was approved by CUREC at the University of Oxford.

Table 2: Study participants quoted in this paper, and their interviewee codes

Project	Participant 1	Participant 2	Participant 3	Participant 4
AshLi	Classical Archaeologist (ex-teacher) (ASHLI1)	Technologist (Classics background) (ASHLI2)	Ancient Historian (ASHLI3)	Ancient Historian (ASHLI4)
PVis	Poet (PVIS1)	Linguist (PVIS2)	Computer Scientist (PVIS3)	

Findings

We have identified four key themes which are most important in relation to the study's aims. In line with the distinction between research technologies and ICTs, we have chosen to focus on presenting the findings which relate to research technologies.

Embedded technology brings new practices, and new practices affect embedded technology

The relationship between embedded technologies and interdisciplinary practices was found to be bi-directional; embedded technology affected interdisciplinary practice, and interdisciplinary practice affected embedded technology. By 'embedded technology', we mean technologies which were extremely central to each project; technologies which were the most deeply rooted in the interdisciplinary workings of each case, and without which the project would cease to be recognisable. Technology represented a common site within interdisciplinary research which was shaped by the researchers and by the tensions between them, whilst simultaneously shaping the researchers' practices. For example, Reflectance Transformation Imaging (RTI) was discussed at great length by the AshLi interviewees (see fig. 1); all researchers recognised the technology as highly embedded within their project:

> Now nobody really has to explain what… this witchcraft [is], it's become a mainstream technology. We represent one of the projects for who RTI wasn't strange, it was a real bread and butter technology. (ASHLI1)

In a similar way, the Poem Viewer tool was discussed by interviewees from the PVis project: it was the only 'tool that came out of [the project]' (PVIS2). Such statements expressed by interviewees suggest that it was the most embedded technology of the range of tools they used; it was the technology which was spoken about most often, and the ways in which participants described it conveyed it as most centrally important to the project (see fig. 2).

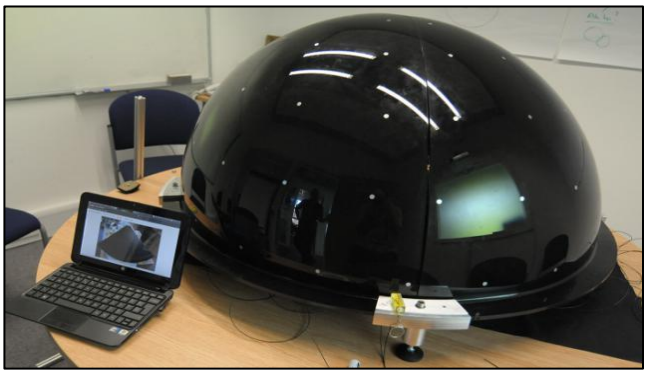

Figure 1: Reflectance Transformation Imaging (RTI) hardware (Reflectance Imaging, 2014)

PVis researchers gave corresponding accounts of interdisciplinary practices during the design of Poem Viewer. 'We would have a discussion, I would go and build something and then give it to them, and then they would give me feedback,' explained the computer scientist (PVIS3). The poet added:

> When we were seeing, and using, and critiquing the tool, that was an effective kind of collaboration, [the computer scientist] would set up a site with different versions of the tools, and we would go in and play with them and use them, and fill out a questionnaire. (PVIS1)

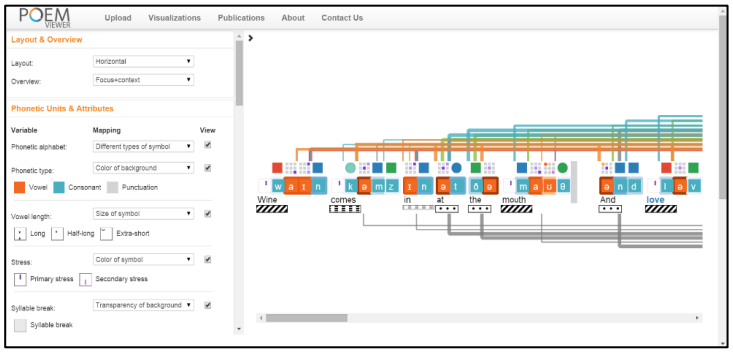

Figure 2: Screenshot of Poem Viewer tool on the browser (PVis) (Poem Viewer, 2012)

So how did this suggest a relationship between the level of embeddedness of the technologies in each project, and interdisciplinary practices?

> I was sceptical at the beginning about the ability of computer scientists to create a tool that, instead of asking me to adapt my scholarly practices to the available technology, would actually bring the technology to me, and make it useful for me to pursue what I wanted to pursue. (PVIS1)

The poet was initially wary of the ability of a computer scientist to design a technology suitable for poetic practices, rather than focussing on aspects important from a technological point of view. But this was not the case, and the Poem Viewer therefore effectively acted as a site for disciplinary values to be negotiated. Not only does this suggest how the poet shaped Poem Viewer, but moreover it hints at a bi-directional relationship of 'change and effect' between the most embedded technologies and new practices of the researcher-users (here, the poets). The poet's sentiment is corroborated in an article she wrote about the project, towards which she directed me: 'the thinking [I did] about poetry in response to this project is thinking I probably wouldn't have done without the pressure of the machine… it [has], somewhat to my surprise, intensified… my lifelong practice of observing how poems operate' (Coles, 2014, p.63). This further suggests how Poem Viewer shaped her practice. This initial scepticism about changing practices followed by an unexpected, and fundamental, change in practice was also acknowledged, although to a lesser extent, by the linguist and the computer scientist during their co-creation of the tool.

ISBN 978-1-86220-324-2

The findings also suggest that the highly embedded RTI had a bi-directional relationship with practices on the AshLi project: 'there are some things that have never been legible, but [now] we've been able to read' (ASHLI1). This indicates that RTI had a substantive, and indeed positive, impact on changing the practices of the Classicists and Historians. In parallel, the Ancient Historian said that 'the technological experts… thought we were after automated reading processes, and that's not what it's about' (ASHLI3), suggesting on the flipside that the researcher-user's (here, the Classicists') practices affected the creation of the technology.

Level of traditional technological engagement and interdisciplinarity affects appropriation

Researchers from different disciplines appropriated technology across the cases in ways generally pertaining to their disciplinary backgrounds' traditional relationships with technology. By this, I mean that the interpretative flexibility of each technology shifted according to the differing 'historical' perspectives on digital technology of each researcher. Researchers' diverse disciplinary backgrounds across the cases shaped technology to differing extents, and researchers both adopted and adapted these technologies. How researchers interpreted, constructed and negotiated their use or design of technology within the context of interdisciplinary research (IDR) differed according to the disciplinary 'make-up' of each project and the technologies involved.

The most interesting way in which this manifested itself was through relationships between different disciplinary methodological practices and the use of technology. All PVis researchers acknowledged the different methodologies brought to the project by researchers, and conceptualised their three disciplines – linguistics, poetry and computer science – according to their qualitative and quantitative backgrounds, with a traditionally better understanding of technology firmly rooted at the quantitative end. The linguist took the role of the interpreter and, as expected, the computer scientist was understood as coming from the most quantitative discipline:

> Putting poets and computer scientists together is unusual because there is such a vast divide… [and] linguists are in a really interesting provisional space between the two. How can we quantify in a way that will aid instead of impede the qualitative experience? (PVIS1)

The linguist added, 'I was in the middle as the linguist, I knew a bit about computing so I was kind of the interpreter in the middle' (PVIS2). Researchers appeared to appropriate Poem Viewer as a site which could help to resolve these methodological differences through the very act of the different disciplines working collaboratively to create the tool. Poem Viewer was both adopted and adapted during the IDR. It is interesting, however, that whilst Poem Viewer was discussed in depth by all three interviewees, prioritisation of certain tools which contributed to its creation was different in each of the interviews. The linguist spoke in a focused way about SemTag, a linguistic semantic tagger used at the backend of the tool; the poet focused mainly on the outputs Poem Viewer can create; and the computer scientist spoke most about the programming languages and web browser which supported the tool. Focusing on three different elements of the same tool represents the interpretative flexibility of Poem Viewer and its diverse appropriation by different disciplines, while suggesting how researchers used the element of the technology with which they were most familiar in order to better understand other disciplinary approaches to, and practices with, the same tool. The researchers on PVis appropriated technology to break down disciplinary boundaries in this way, according to their home disciplines' traditional level of engagement with technology.

Similarly, the AshLi archaeologist, with an interest in film-making, mused 'it's nice to see [our epigrapher] who learnt the old-fashioned way to do epigraphy [take] to RTI like a duck to water' (ASHLI1). However, the technologist on the project explained that perhaps the epigrapher did not learn to use the tool quickly due to any feature inherent within the technology, but rather, because he had spent time explaining it to her in a way with which she would feel comfortable:

> You always have to be careful with Classics in general because these objects are so old… [they] are wary of applying techniques which may hurt the object. So [I] have to be very clear about [my] intentions so everybody in the room feels comfortable with what's happening. (ASHLI2)

The technologist's heightened level of understanding of RTI, and thus his simplified description of it, seemed to encourage an ease of technological understanding in the 'technophobe' epigrapher (ASHLI1). From the technologist's point of view it seemed that the epigrapher appropriated RTI according to his instruction, thereby

ISBN 978-1-86220-324-2

breaking down traditional qualitative-quantitative disciplinary barriers between them. In this way, the data suggests that practices with RTI, and the technology itself, were socially negotiated according to disciplines.

Boundary breaking: active appropriation into home disciplines

Researchers across both cases were generally very enthusiastic about working with other disciplines within their research, and had actively sought out IDR projects which might allow them to develop new skills and knowledge. '[We attempt to] bridge the professional gap between computer scientists and poets' explicitly reads the third slide of a PVis PowerPoint presentation explaining the project's aims to funders. The project actively set out to break down disciplinary boundaries, and PVis researchers had an awareness of their role in appropriating the technology to break down boundaries. The poet spoke about how visualisations of the ways in which words were spoken, created by the computer scientist, reflected back into her own disciplinary practice: 'those glyphs… sent me back to Ezra Pound's 'The Station of the Metro', and changed the way I thought about the poem' (PVIS1). This triangulates with a comment in her article which reads, 'working with and for the machine has altered how I read poems' (Coles, 2014, p.63). The poets and computer scientists both actively shaped these visualisations according to their disciplinary backgrounds, and in turn the poets were very open to the visualisations shaping their disciplinary practice.

Appropriation of technology into home disciplines by the researcher-users also occurred in the AshLi project. 'The mobility of the material. The stuff that we're working with, it's not just massive in quantity, but some of these pieces are a tonne heavy… [imagine] a researcher carrying around forty tonnes of stone on their laptop!' (ASHLI1). All disciplines on AshLi seemed to understand how RTI could change, and indeed was already changing, practices within their own sub-disciplines. This appeared to be made evident to them both during the construction of the RTI technology, as well as through their use of the technology, when they could empirically 'see' benefits within their own fields. For example, an ancient historian repeatedly used the word 'exploit' to emphasise how technology could benefit his work – his work which, as already discussed, was a factor in shaping the RTI originally.

Constructing the design

The design and implementation of the research technologies in AshLi and PVis were actively moulded and shaped by different disciplines during interdisciplinary practice. The data suggests that researchers' interpretations of the technologies, in terms of how they could be appropriated, varied according to disciplinary perspectives in such a way that the design processes also broke down disciplinary boundaries.

> The original idea was from… a medical imaging specialist working on mammograms. He would show me these image captures, what the medics would be looking for in terms of abnormalities…and then we would think about how you would do that in terms of sorting out, on a piece of wood or stone. [The engineers] had a lot of sympathy even though they didn't know any Latin…on the other hand I don't know much about mammography either! (ASHLI3)

This explanation by the ancient historian of the initial conception and design of RTI suggests the shaping of the technology by multiple disciplines. 'It's one thing understanding the Classics to shape the technology [but] understanding the science can shape it as well' (ASHLI2). Likewise, the PVis poet said, 'If [people] can understand the brain this way, they should be able to understand a poem this way!' (PVIS1). Disciplinary knowledge and perspectives converged within the design. Furthermore, the computer scientist on the project explained her personal experiences of their iterative design practices on the project:

> It was important for [the poets and linguists] to give feedback to me, from there I could judge… the changes I needed to make. You have to have a lot of patience… an iterative process of building a prototype and then having the humility to say, I'm wrong, I need to make a change, that's important… computer scientists can be quite arrogant. When I was building the tool I noticed [a poet] having problems with her machine…it occurred to me that if I were to build a Java standalone application, [I would have to make] it compatible with their machines. (PVIS3)

She not only emphasised how all three disciplinary perspectives contributed to the design of the Poem Viewer tool, socially negotiating the technology, but moreover she acknowledged that the process was not easy. She appeared to have a deep awareness of researchers' from other disciplines choices in the design process, even causing her to reflect back on her own disciplinary background, and it is through this process of shaping and

ISBN 978-1-86220-324-2

designing the technology that boundaries were broken on the project, disciplinary ideas integrated, and interdisciplinary practices took place.

Conclusions

Technology is key in understanding the modern conception of interdisciplinary research within Higher Education. Two key conclusions can be drawn through reflection on commonalities across the findings. Firstly, the findings suggest that innovative and embedded research technologies shape new interdisciplinary research practices and knowledge co-creation. In turn, interdisciplinary researchers' practices and disciplinary tensions also shape technologies. This iterative process of mutual shaping assumes different nuances according to the disciplinary 'make-up' of different projects, the technologies involved, and the ways in which the researchers appropriate technologies according to their disciplinary backgrounds – that is, how they interpret or construct their use or design of technology within the context of interdisciplinary research. These findings corroborate the findings of Fry and Schroeder (2010) and Fry and Talja (2007, p.116) who investigate the 'mutual shaping' of digital resources and academic fields. Fry and Schroeder's (2010, p.257) work in particular emphasises the 'increasing importance of the digital' in reconfiguring boundaries within IDR landscapes.

Secondly, the findings suggest that technology can be constructed through the integration of disciplinary perspectives. Researchers from different disciplines both adopt and adapt technologies, and through these processes, disciplinary boundaries can be broken down, and knowledge can be co-created. This study provides aesthetically-rich empirical evidence to suggest that research technology is socially negotiated according to different disciplinary perspectives within the context of IDR. This was illuminated by the use of interpretative flexibility as the theoretical lens, which captured researchers' diverse perspectives on technology and interdisciplinary practices. Fry (2006, p.301) frames her study, which investigates information practices within different scholarly communities, similarly, and found that 'technologies… are shaped by disciplinary rituals and practices'. This is also consistent with Fry and Schroeder's (2010, p.263) findings that 'tools are being shaped by different disciplines'. Disciplinary backgrounds were found to be important in the appropriation of technology to break disciplinary boundaries, and researchers shaped and designed technologies in a multitude of ways according to their 'home' disciplinary methodologies, their traditional perspectives on technology, and the influence of the wider interdisciplinary group. This resonates with the work of Collins et al. (2011, p.76) who found that researchers' uses of digital technologies are affected by existing disciplinary habits and preconceptions. Haythornthwaite et al. (2003, p.158) similarly explains that 'interdisciplinary differences can predispose [the researcher] to a particular view of a supposedly common [technology]'.

The generalisability of this small sample, however, is weak and it might therefore be wise to consider whether the findings would have been radically different had more cases been used, or if neither case involved any innovative research technologies. Future research could also investigate the institutional effect of technology mediation on interdisciplinary research within Higher Education, and it would benefit this study to be contextualised in this wider macro-environment. Further investigations of the organisational, political and economic factors which can open the 'black box' of technology in this way would be useful (Bijker et al., 1987, p.8). 'Computational techniques are not merely an instrument wielded by traditional methods… they also allow the recombination of disciplines within the university itself. Computational approaches facilitate disciplinary hybridity' (Berry, 2011, p.13). Nevertheless, this study has succeeded where, according to Haythornthwaite et al. (2003, p.144), others 'fail to acknowledge the negotiation of practices and coevolution of practices and technology'. Additionally, this paper highlights that collaboration around research technologies has not yet been explored very much in the field of networked learning, nor has the potential for building on other concepts from STS, such as Actor-Network Theory (Adams and Thompson, 2014; Clough et al., 2010). The findings therefore hold broad implications for the promotion of a more nuanced view of modern interdisciplinary practice, and the study lends empirical evidence to support the use of theoretical frameworks from the social shaping perspective in related research in the future, hence potentially enabling greater contributions to the fields of educational technology, interdisciplinarity, and beyond.

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ISBN 978-1-86220-324-2