A case study of computer science lecturer's selection and use of digital tools in an Irish Technological University

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Abstract

This research explores factors that influence the selection and use of digital tools as part of computer science lecturer's professional practice. The research takes the form of an intrinsic case study and as such the intent is to better understand and identify the uniqueness of the case by focusing on computer science lecturers professional practice. The author draws upon activity theory as its theoretical framework to expose explanatory and contextual insight, whilst not attempting to provide a complete overview of the domain. The primary data was gathered through semi-structured interviews with five computer science lecturers. It is evident from the literature that among others, user experience and compatibility with teaching pedagogy should be factors to be considered when selecting digital tools and this study offers confirmation these. Furthermore, literature suggests that the overuse of too many digital tools or 'digital tool sprawl' is an emerging issue in higher education. This corresponds with a significant finding from this study, which reveals an unintended consequence of computer science lecturer's digital agency, typically characterized as 'positive', can, as part of professional practice, actually exacerbate the issue of 'digital tool sprawl' in higher education.

1. Introduction

With the widespread acceptance of the use of digital tools in education, comes an expectation that lecturers should use digital technology as part of their professional practice. This expectation is now ubiquitous, regardless of the nature of delivery; face-to-face, fully online, blended or hybrid. Furthermore with the proliferation of applications and other technology now available, further strengthened by the increased reliance on technology due to Covid-19 restrictions, this posits a number of considerations for the practices of faculty.

'Digital tools' is a broad 'catch-all' term to encapsulate the use of technology by faculty in higher education. Generically, digital tools can be defined as "programs, websites or online resources that can make tasks easier to complete" (UK Gov, 2022), while a more specific reference to digital tools as used in science is "[digital tools]... as used in scholarly work that

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go beyond the individual computer and represent digital media or online-based, networked software systems" (Albrect et al., 2021, p. 52).

Technological Universities (TU) are relatively new in the Irish tertiary educational landscape, having been formed through the amalgamation of two or more former Institute of Technologies (IoT). There are now five TUs in Ireland, in addition to two existing IoTs. In this newly emerging environment, there is quite an amount of autonomy afforded to computer science (CS) lecturers in the selection of digital tools. The provenance of this research has emerged from recent observations of professional practice as a CS lecturer in an Irish TU, where the activity of the selection and use of digital tools is not fully acknowledged or understood. The overall aim of this paper is to make a contribution to the understanding and motivation behind the selection and use of digital tools by CS lecturers and identify any significant consequences. This will be achieved by answering the following research questions.

- RQ1: What factors influence lecturers when selecting digital tools to use as part of their professional practice?

- RQ2: What (if any) significant consequences emerge as a result of this case study?

This small scale case study provides a specific focus for CS lecturers in an Irish TU, to reflect and inform their scholarly activity of professional practice. Along with confirming findings from the literature, in this paper, the author argues that while the existing dominant body of knowledge related to digital agency is primarily viewed as a positive trait, this case study reveals that in practice, contradictions in activity theory show that digital agency in CS lecturers has an unintended consequence of exacerbating the issue of the overuse of digital tools. This research is further distinguished by its use of activity theory as its theoretical framework as opposed to more common frameworks such as TPACK (Mishra & Koehler, 2006).

It is important to note that this research is not offering a complete analysis of the domain, however the research does offer specific insight into the selection of digital tools and offers a number of paths to further research at the juncture of digital agency, technology integration and higher education.

2. Literature Review

To explore the literature around the research domain, an initial search of SCOPUS using the key terms of 'digital tools' or 'digital technology' and 'digital agency' or 'digital competency' and 'technology integration' resulted in 205 papers, subsequent inclusion of 'higher education' as a search term resulted in 57 papers, which were reviewed and reduced to 23 relevant papers. The examination of ACM and IEEE broadened the scope for relevant literature. Finally, snowball referencing was utilized as an additional approach to identifying appropriate research to ensure a comprehensive review of the literature.

2.1 Digital tool selection and use in educational settings

Digital tools have a number of uses and functions in educational professional practices. These range from 'operational technology', involving day-to-day uses such as managing and distributing content, to enhancing teaching and leaning through the use of 'educational technology' (Davies et al., 2008). Additionally, CS educators also have to contend with the

learning and instruction of technology itself, 'technology education' (Jones & Rocco, 1999) which offers challenges such as professional development support and keeping up-to-date (McGarr et al., 2020).

Literature suggest there are factors to be assessed when determining the selection and use of digital tools as part of teaching and learning. Trust (2020) grouped four considerations to evaluate:

> 1) User experience
> 2) Learning experience
> 3) Accessibility
> 4) Cost, Privacy and Data (Trust, 2020).

While educational technology is well-intentioned and educators have many reasons to implement educational technology such as, facilitating creative activities, providing flexible learning environments, increased student engagement and the ability to give instant feedback (Haleem et. al, 2022), literature also suggests that the overuse and saturation of educational technology can create end user technology overload (Harris et al., 2015). A recent EdTech report stated that there was a 90% jump in the use of education technology products (EdTech, 2022) and from a student perspective, a separate report found that 27% of learners felt that they were being assigned too many different digital tools (TopHat, 2022).

While it is accepted in the literature that educational technology can enable innovation in teaching practice (Lai et al.,2018), as discussed by Eguland et al, (2017), educators approaches to educational technology is essential for the integration and implementation to be successful as part of an academics professional practice.

2.2 Integration of digital tools in educational settings

The integration of digital technology and tools in education and teaching activities is challenging for educators (Brooks & Bengtsson 2022, Viberg et al., 2020). While technology integration models such as SAMR (Puentedura, 2006), TPACK (Mishra & Koehler, 2009), DigCompEdu (Redecker, 2017) are referenced throughout the literature and have been designed to evaluate and inform the selection of digital tools. Kuhn (1996) however, states that "no [model] ever solves all the problems it defines," and "no two [models] leave all the same problems unsolved" (Kuhn 1996, p. 110). Additionally, no single model may be universally valuable, understandable, or useful to all stakeholders (Kimmins & Hall, 2018).

Findings from Mei et al., which utilized the TPACK model as its theoretical framework, indicate that some educators "are more innovative than the majority in their use of digital learning tools" (Mei et al., 2019, p. 26) and that there is a need to "ensure that both the individual teacher and the educational institution reach the goal of coordinating the use of digital learning tools" (Mei et al., 2019, p. 27). These findings from the literature indicate that there is a discrepancy between individual lecturers and organizational capacity to cohesively integrate digital tools.

2.3 Digital agency

The terms 'digital agency' and 'digital competency' are increasing used in public discourse, however how these concepts are defined and understood is unclear (Spante et al., 2018). Plassey et al. (2018, p. 426) define digital agency as "consisting of digital competence, digital

confidence and digital accountability - is the individual's ability to control and adapt to a digital world".

In an educational context, agency is a "prerequisite for conscious transformation" (Aagaard & Lund, 2019, p.7) and the tendency of educators to integrate educational technology lies with the individual agency of the lecturer (Omingo, 2019). By proposing a mentorship approach to developing teacher digital agency, Kussen & Agnew (2022) designates digital agency as desirable and this is supported by Anand (2022, p. 64) stating that educators "need to have digital agency". With the pervasiveness of digital tools and ICT usage in daily life, which is reciprocated in an educational environment, digital agency benefits the integration of technology into professional practice in a "meaningful and capital enhancing way" and not simply "function with technology" (Pearce & Rice, 2017, p. 2).

Due to the ever evolving nature of the computer industry, there is a certain degree of inherent digital agency and autonomy afforded to CS lecturers to select and use digital tools as required. A survey of predominantly Irish lecturers in mathematics, a discipline which is a fundamental pillar in all computer science programmes, shows that over 80% of lecturers selected the technology to use independently (Ní Fhloinn & Fitzmaurice, 2021). Even considered outside the the extenuating circumstances of Covid-19 restrictions, this figure presents a though-provoking trend in terms of the individualistic and ad-hoc approach to selecting and using digital tools by academic faculty.

2.4 Gaps in the literature

The importance of technology in the classroom is reflected by the literature which reveals that there is much recent research related to secondary school teaching, focusing on teacher use of technology (Yiannoutsou et al., 2022, Yildiz, 2021, Spiteri & Rundgren, 2020). Furthermore there is evidence of studies at third level, related to digital skills and teacher education (Kussen & Agnew, 2022, Rodrigues, 2020). While literature does exist in the relative domain (Falloon, 2020, Sjöberg & Lilja, 2019), there appears to be an under representation at the axis of digital agency of lecturers, technology integration and the selection of digital tools as part of professional practice, which this paper aims to address.

3. Theoretical Framework

My ontological perspective is based in social constructivism, where there are multiple different realities created by individuals in groups. Therefore, my epistemological position for this case study is to interpret the reality of CS lecturers selection and use digital tools as part of professional practice. I will achieve this through the use of an inductive methodology, developing truth based on observations from an empirical case study.

The theoretical framework for this research was holistically guided by Activity Theory (AT) which was pioneered by psychologists Vygotsky (1978) and Leontyev (1981). Broadly aligned with social constructisvim, AT has been used to describe human activity in a variety of contexts including education and teacher education research (Ellis et al., 2010; Feldman & Weiss, 2010; Thorgeirsdóttir, 2015). As part of this theoretical framework, the Activity Systems Model (ASM) models an activity using seven elements that play a crucial role within an activity.
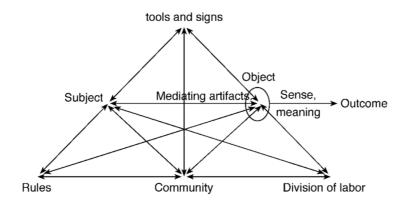
Figure 1: The structure of a human activity system (Engeström, 1987, p 78)

Cultural, Historical Activity Theory (CHAT) is an adaptation of activity theory by Engeström and is now a well established theoretical framework (Engeström, 1999). ASM focuses on 'the system' view, while also taking into consideration participants practices and beliefs (Cultural) and situational context (Historical). Overall CHAT offers the ability to demonstrate the complexity of human activity and using ASM it is possible to model CS lectures activities in the selection and use of digital tools, therefore is an appropriate theoretical lens to utilize for this case study.

4. Methodology and Methods

This section identifies the overall research methodology implemented and offers reasoning for this selection. Ethics was considered throughout, no personal identifiable information is provided and ethical approval was attained prior to undertaking the study.

4.1 Case study

A case study is a research method that allows the exploration and in-depth understanding of a single person, group, event or community. Yin states that "case studies can be used to explain, describe or explore events or phenomena in the everyday contexts in which they occur" (Yin, 2009, p. 3), as this research is centered on the investigation of scholarly activity it is an appropriate methodology to undertake this research.

4.2 Data collection

Data for this case study was collected through semi-structured interviews with participants. As this case study is "driven by a desire to know more about the uniqueness of the case rather than to build theory or how the case represents other cases" (Mills et al., 2010, p. 183), the participants were selected on the basis that they have direct experience with the case in question. All participants are CS lecturers, work in the same department of an Irish TU and have experience using digital tools as part of professional practice.

Five semi-structured interviews was the principal means to collect primary data. The interviews were held online in June 2022 using Microsoft Teams. Interviewees were provided with a copy of the questions in advance. From these interviews over three and a half hours of audio was recorded, once transcribed this data amounted to over thirty typed A4 pages

(approximately 750 words per page, over 25,500 words). Ethnographic data was collected through an analysis of organizational communications, online service catalogue provided and historical departmental software requests.

4.3 Data analysis

Initial examination of interview data was informed by thematic analysis and further analysis was guided by inbuilt structures within the wider AT theoretical framework. Coding was performed on the semi-structured interview data, this was performed to allow the researcher to become familiar with the data and the case being examined. Thematic analysis was performed using the six-step approach proposed by Braun and Clark (2006), then grouped and organized to form themes. This process led to the identification of five themes, these are articulated in Section 5.1.

ASM, a triangular activity system describing the structure of human activity (Engeström, 1987) was employed to visually represent the activity using its seven constituent elements; subject, tool, rules, community, division of labour, object and outcome. Interview questions were mapped to the elements to assist in the generation of the activity model in addition to being guided Mwanza's (2002) eight step model. This resulted in the visual representation of a human activity, the selection of digital tools as part of CS lecturers professional practice. This is presented and discussed in Section 5.2.

Once an activity is modeled, ASA provides an analytical framework to analyse the data. One of the primary benefits of AT is the exposition of 'contradictions' that exist between elements. Contradictions are tensions that exist within activity systems (or between multiple activity systems) and they manifest themselves as "problems, ruptures, breakdowns, clashes" (Kuutti, 1995, p. 16). While contradictions are "always present although not always perceivable" (Nunez, 2014, p. 70) they are "important for exploring possible shifts that may occur and learning that might emerge" (Davis, 2012, p. 96). Engeström (2001) identifies four layers of contradictions, primary, secondary, tertiary and quartenary contradictions. For the purposes of this case study, analysis will be bounded to secondary contradictions, which are contradictions that occur between different elements of the same activity system.

5. Findings and validation

Five themes emerged as a result of thematic analysis, the first two themes are generalizeable and have previously been identified in literature. The final three themes are specific to this case study and are used to inform subsequent primary data analysis.

5.1 Thematic analysis

The first theme to emerge is that for digital tools to be considered or utilized, they must be compatible with pedagogy. From the data it is evident that for CS lecturers to invest time and effort into selecting and using a digital tool, it should have potential, replicate real world experience and must help support student learning.

> *"[a digital tool]... must fit into pedagogy and not be used 'just because'"*
>
> (Participant A)

The second theme to emerge is that digital tools must have an intuitive and consistent user experience. Digital tools should be clear and not distracting to students while also being cognizant of students who are not tech-savvy, to not overwhelm them. A related trait here is that CS lecturers preserve with existing digital tools that are the 'status quo' as students are familiar with the user experience of them.

"Most students appear happy with Blackboard and while it is not perfect, it is consistent for most of my needs."

(Participant D)

The third theme that emerged is that there is a preference to pick and choose digital tools as required, to avoid digital tools that are proprietary and tend to have too many options and features. Availability, composability and integration are important considerations which can be problematic with large scale digital tools.

"I'm perfectly happy to use a combination of tools if each tool does its own job well... overall I will select whatever is easy, immediate and works."

(Participant C)

The fourth theme to emerge is how digital agency is palpable in the participants of this case study. All participants self identified as 'early adopters' or 'innovators' as part of Rodgers (2003) Diffusion of Innovation model and this is also observable from the data where CS lecturers are interested in new technology, prefer independent learning and regularly experiment with ease.

"I am very open to trying new tools and this is typically driven by my own readings and research"

(Participant E)

The final theme to emerged was that of digital tool sprawl, this was particularly noticeable in communication where email, Blackboard, Teams, Slack, Discord, WhatsApp and Signal were all identified as in use. Overall in the interviews, 48 different digital tools were identified from the primary data and from other ethnographic data, 86 different digital tools are requested by lecturers in the department each year.

"I can see how it happens, you know, because you know guys just like a particular tool and then you expect somebody else to start using that tool."

(Participant B)

5.2 Selection and use of digital tools

Presented in the form of an ASM, produced using primary data, Figure 2, adapted from Engeström (1987, p. 78) is a visual representation of the case of CS lecturers activity in the selection of digital tools to use as part of professional practice.
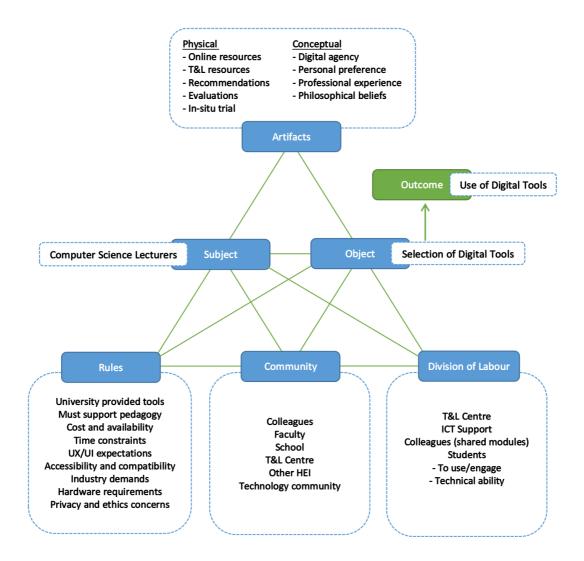
Figure 2: Activity System Model (Source: Author, from primary data)

Figure 2 displays how each element in the activity system is composed of discreet constituent parts for this case. What is evident from this model is that while 'Community' and 'Division of Labour' elements are significant to CS lecturers, the elements of 'Artifacts' and 'Rules' are clearly predominant in terms of their exposition of considerations for the activity. This ASM was then utilized for further analysis through the identification of contradictions. While it is possible to identify a large number of contractions in this activity, it is not possible to examine all contradictions within the bounds of this case study, this is expanded upon and further explained in Section 5.3.

5.3 Relevant contradictions

In this activity, CS lecturers are the subjects, motivated towards the attainment of the object (the selection of digital tools). The outcome of this activity is the use of digital tools as part of professional practice. The determination of relevant contradictions for further exploration has been informed by the results of thematic analysis, in order to offer an explanatory account, which corresponds to the aim of an intrinsic case study (Stake, 1995).

The contradictions identified to expose and examine for this study are secondary contradictions between A) Rules and Subject, B) Division of Labour and Object and C)

Artifacts and Object. These are visually represented in Figure 3, adapted from Engeström (1987, p. 78) and elucidated further below.
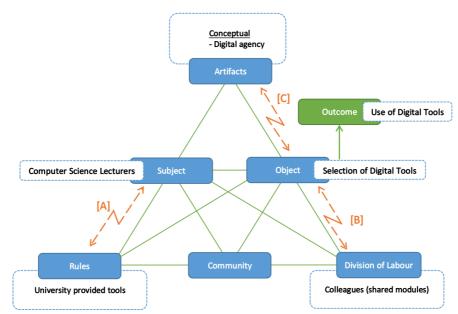

Figure 3: Relevant contradictions (Source: Author, from primary data)

The first contradiction to be examined is a contradiction between CS lecturers (subject) and informal rule to use University provided tools (rules). This conflict manifests itself where there is an array of provided digital tools available but there is no mandate to use them. The contradiction here is that with this requirement lacking, individual lecturers are free to pick and choose any digital tool. All participants in this case study have indicated that they have deviated from University provided tools for various legitimate reasons. However, the unintended consequence of this flexibility is the propagation of the use of different digital tools by CS lecturers.

The second contradiction identified is between colleagues (division of labour) and the selection of digital tools (object), in this instance, in the case of shared modules, if a colleague is using a specific digital tool, you are obliged to also use this tool if you are part of the teaching team. The contradiction here is that, for a lecturer of a shared module, the choice of digital tool has already been made and therefore there is no selection of digital tools (object) to be made. All participants in this case study have had previous or current experience of this where the digital tool in use was either 1) not their choice and/or b) not their normal digital tool. This contradiction has lead to an increased diversity of digital tools that lecturers utilize.

The final contradiction and the most significant one for the purposes of this case study is a contradiction between digital agency (a conceptual artifact) and the selection of digital tools (object). From the data gathered, CS lecturers have displayed an inherent digital agency to investigate, trial and incorporate a variety of digital tools based on personal preferences, philosophical beliefs and professional expectations. Here, the unintended consequence of this contradiction is the proliferation of digital tools by CS lecturers, which has accentuated an identified theme of digital tool sprawl.

6. Discussion

To answer RQ1, from the data it emerges that there are many factors that are considered by CS lecturers when selecting digital tools to use as part of professional practice. Once categorized into themes, some emerge as common factors, such as supporting pedagogy and requiring a positive user experience, which have previously been identified (Trust 2020, Hirsh-Pasek et al. 2015; Koh, Chai & Tay, 2014). While other factors such as 'one tool for one job' appears to be quite specific to CS lecturers, perhaps a call back to the historical Unix philosophy of doing one thing and doing it well (Salus, 1994).

Of the technology integration models identified in the literature, the simplicity of SAMR (Puentedura, 2006) is most reflective of what is occurring 'one the ground' with CS lecturers in an Irish TU. However, it is important to note that the use of SAMR is not as prevalent across the literature as other models as it is not theorized or connected to any theoretical framework. SAMR is open to criticism as it is too simplistic and does not take into account context and overgeneralizes (Hamilton et al., 2016).

For CS lecturers in an Irish TU, this study also confirms that selecting tools for operational and technology education purposes is for the most part predetermined as lecturers use institute provided tools as standard. However it is evident that there is also an individualized and ah-hoc approach to selecting digital tools by lecturers, specifically for teaching and learning purposes. This is representative of findings from a systematic review by Lillejord et al. (2018) which found that "academics appear not be using a scholarly approach when implementing technology in education" (p. 4, emphasis in original). This reflective of, that while pedagogy is considered, it is in the context that digital tools are considered only as deployed tools, copying existing practices (Orlikowski & Iacono, 2001) rather than understanding how digitization affects pedagogy.

To address RQ2, a significant consequence that is observable as a result of this case study is the emergence of a correlation between CS lecturers digital agency and the overuse of technology. Through the theoretical lens of activity systems it is possible to reveal contradictions, which assist in identifying "unintentional deviations from the script [which] cause discoordinations in interaction" (Engeström et al., 1991, p. 91). This research has highlighted three such contradictions, which when viewed individually do not appear to be of consequence, however when viewed collectively offers an insight into how this non-scholarly approach can manifest to the detriment of an activity. Indeed these contradictions would otherwise be difficult to identify as "they may not be easily acknowledged, visible, obvious, or even openly discussed by those experiencing them" (Murphy & Rodriguez-Manzanares, 2008, p. 446).

To illustrate this, one quote from the interview data stood out, where Participant C stated "digital tool sprawl one is not one I'd be too concerned with" and then in the very next sentence proceed to explain how they were "perfectly happy to use a combination of tools if each tool does its own job well" (Participant C), thus revealing how multiple digital tool usage can originate. The consequence illustrated by this contradiction, relates to digital agency, which is typically viewed as a 'positive', however as this case study has revealed, this 'positive' artifact can have a detrimental effect on the professional practice of CS lecturers by actively contributing to digital tool sprawl. This revelation goes in some way to addressing a gap identified in the literature review.

7. Conclusion

This is a case study of the section and use of digital tools by CS lecturers in an Irish TU. It confirms some common factors and identifies factors specific to CS lecturers that influence the selection and use of digital tools. Furthermore, this case posits it that there is an individualized and ah-hoc approach to selecting and using digital tools by CS lecturers and that this non-scholarly approach has an unintended consequence of exasperating the issue of digital tool sprawl.

This was achieved through the use of AT as a theoretical lens, where a number of contradictions were identified that when examined offered insight into the consequences of these contradictions. Of these, the most prominent original contribution is the identification of the contradiction between digital agency, a conceptual instrument of CS lecturers and the selection of digital tools. This leads to unintended consequences of the proliferation of digital tools by individual lecturers. This is further supported up by thematic analysis of the data, which identified the emergence of 'digital tool sprawl' as an issue. An understanding of digital tool sprawl would not have been possible solely through thematic analysis, however examination through AT offers this valuable insight.

Future research options to emerge from this study are to expand the case study across faculty or across multiple institutions or to explore the possibility to design a scholarly approach to the selection and use of digital tools as part of lecturers professional practice.

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