Understanding Education Technology Integration Experiences among Engineering Educators: A Cultural Historical Activity Theory Approach

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Abstract

Although the University of Cape Town has implemented various education technology projects in the last two decades, the disruptions experienced during the #FeesMustFall movement and the COVID-19 pandemic point to challenges with integrating technology successfully, highlighting the need to better understand technology integration in higher education. Based in the Engineering Faculty, I adopted a Cultural Historical Activity Theory (CHAT) perspective to understand the experiences of engineering educators with regards to education technology integration in a department. A qualitative case study with semi-structured interviews was conducted with engineering educators. The data was analysed according to the categories in CHAT. Individual educator analyses were presented as activity systems. These were then synthesised to a departmental level understanding. I found that all educators integrated education technology to varying degrees. These included the university's learning management system, Microsoft PowerPoint, document cameras, and various engineering technologies. Educators integrated education technology to improve the practical demonstration of engineering concepts, prepare students for the workplace, and improve the efficiency of certain tasks. Their integration efforts were mediated mainly by the university's infrastructure and their access to institutional technologies. Nondirective approach by the departmental and faculty leadership provided educators with the freedom to integrate education technology, although, some educators expressed a desire for increased leadership intervention. Technical and pedagogical support services from the university provided resources and support for integration. The technologies integrated by the educators were informed by their preference for teaching resources that visualised theory. Educators were concerned with the impact of lecture recording on attendance, highlighting sustainability issues of this technology. As all participants integrated education technology independently, future studies may benefit from understanding less active users' experiences, the contribution of support services, and the role of departmental leadership.

Keywords: Education Technology Integration, Engineering Educators, Cultural Historical Activity Theory, Higher Education

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Plagiarism Declaration

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List of Abbreviations and Acronyms

CET	Centre for Education Technology
CHAT	Cultural Historical Activity Theory
CILT	Centre for Innovation in Learning and Teaching
CK	Content knowledge (TPACK)
EBE	Faculty of Engineering and the Built Environment
HE	Higher Education
HEIs	Higher education institutions
ICT	Information and communications technology
ICTS	Information and Communication Technology Services
IT	Information technology
LMS	Learning management system
PCK	Pedagogical content knowledge (TPACK)
PK	Pedagogical knowledge (TPACK)
TAM	Technology Acceptance Model
TCK	Technological content knowledge (TPACK)
TK	Technological knowledge (TPACK)
TPACK	Technological pedagogical content knowledge
TPK	Technological pedagogical knowledge (TPACK)
UCT	University of Cape Town

Chapter 1: Introduction

The use of education technologies has become increasingly intertwined with the 21st century tertiary education classroom. The introduction of learning management systems (LMS) centralised the provision of education resources, as higher education institutions (HEIs) no longer required multiple tools for a technologically-enhanced experience (Weller, 2018). Additionally, education technologies such as videos and open education resources have provided alternative means of access to knowledge (Weller, 2018). These resources, often free, have motivated educators to experiment with flipped classrooms (Huang, Spector & Yang, 2019:26), thus transforming the higher education (HE) experience.

To help define education technology integration, the term can be broken down into parts. *Integration* denotes an "effective implementation" (Davies & West, 2014:843). *Technology* describes the tools required. *Education* points to specific learning outcomes. Together, education technology integration is the efficient implementation of technological tools aimed at achieving specific learning outcomes (Davies & West, 2014:843; Huang et al., 2019:10).

Although earlier studies on education technology integration focused mainly on school teachers (e.g., Inan & Lowther, 2010; Kim et al., 2013; Sherman & Howard, 2012), more recent studies have shifted towards university educators. Adeyelure and Kalema (2019) identified the ideal contextual factors for implementing smart learning environments in HEIs. Englund, Olofsson and Price (2017:84) found that novice educators were more open to conceptual change that promotes teaching with technologies. Onwuagboke and Singh (2016:80) found a positive correlation between staff attitudes and the use of education technologies. These studies point to a growing interest in the integration of educational technologies in post-secondary education environments.

As a developing nation, South Africa HEIs' education technology integration is dependent on infrastructure and literacy skills. However, recent proliferation of mobile devices and social media has assisted with raising technical literacy levels and access to the internet (Ng'ambi et al., 2016:854).

The University of Cape Town (UCT) has implemented various education technology projects such as adopting an LMS, the Classroom Renewal Project, the Laptop Project, etc. (see Chapter 2). Yet, the disruptions from 2015 to 2017 signalled a challenges to ability to integrate education technology. Despite the university's continued efforts to engage with education technologies - e.g., the Lecture Recording Project and an Online Education Policy (see Chapter 2) - the current COVID-19 pandemic and a worldwide shift to remote learning has once again required UCT to reconsider its integration practices.

Although this study took place prior to the COVID-19 pandemic, it is my hope that this research will contribute towards understanding the growing-popularity of education technology among university educators. Due to my proximity to UCT's engineering faculty as an administrative staff member, I will be exploring how engineering educators integrated education technology.

The purpose of this study is to understand the integration of education technology by engineering educators into their teaching. My research questions are:

- What education technologies have been integrated by engineering educators?
- Why do engineering educators integrate education technology?
- What conditions enable engineering educators' education technology integration?
- What conditions constrain engineering educators' education technology integration?

I will locate the study initially in a national, institutional, and faculty context, highlighting elements that shaped education technology integration. Thereafter, I discuss the concepts that related to education technology integration from the literature. The selected model, the Cultural Historical Activity Theory (CHAT), with supplementing models that may assist with understanding education technology integration are also presented. This is followed by the methods chapter which explains the selected research approaches as well as ethical and validity considerations. To present the data, I will introduce the results by educator followed by a synthesised departmental-level understanding of education technology integration. I conclude the dissertation with a summary of findings and future recommendations.

Chapter 2: Research Context

South African HEIs have been focused on infrastructure. Computers were seen as an important tool for teaching and learning, leading to increased accessibility and web literacy concerns (Ng'ambi et al., 2016:849). From 2006, a more pedagogical understanding of education technology developed to identify the intricacies of integrating such technologies (Ng'ambi et al., 2016:851). This was complicated by low technical literacy levels among South African students (Lusigi, 2019:13). However, recent proliferation of mobile devices and social media has assisted in raising technical literacy levels and internet access (Lusigi, 2019:12; Ng'ambi et al., 2016:854).

2.1. Education Technology at UCT

At the turn of the 21st century, UCT began to advocate for "a more systematic approach to education technology" (CET, 2011:4). Thus, in 2004, UCT's Education Technology Policy was adopted (UCT, 2003). The policy aimed to narrow the digital divide between students, as well as to establish staff development opportunities for teaching with technologies, ensuring UCT remains a nationally and internationally competitive HEI.

The policy included "the provision of an appropriate ICT (information and communications technology) infrastructure and technical support to enable effective implementation" (UCT, 2003:3). Therefore, a reliable internet network via Eduroam - an international roaming service with global operators (Eduroam, n.d.) - was secured across all campuses. In 2019, this service was extended to 57 Cape Town public libraries (UCT, 2019), enabling students and staff to obtain secure, reliable internet connection at off-campus locations.

To ensure that the use of ICTs were supported by pedagogical principles, the Centre for Educational Technology (CET) was established in 2005. CET's purpose was to "encourage and support the innovative and effective use of ICTs for educational purposes at UCT" (CET, 2011:4). In 2014, CET merged with the Higher and Adult Education Studies Development Unit to form the Centre for Innovation in Learning and Teaching (CILT) (CHED, n.d.). CILT provides pedagogical support on learning technologies, course design, and staff development (CILT, n.d.), while the Information and Communication Technology Services (ICTS) provides technical support, such as hardware setup (ICTS, 2019). Between 2012 and 2017, ICTS's Classroom Renewal Project upgraded 101 teaching venues with improved equipment and easier access to support via telephones (ICTS, n.d.), thus enabling education technology integration by eliminating infrastructural and setup requirements.

A significant development was the introduction of Vula, UCT's LMS (learning management system), in 2006. Based on SAKAI, Vula allows the creation of customisable sites for courses, projects, and groups, by providing a selection of tools for communication, collaboration, administration, and assessment. To support the integration of Vula into teaching practices, workshops are hosted regularly and resources are provided on CILT's website. The platform itself has a searchable Help function with contact details to the helpdesk. Although Vula is not a requirement, it has become the norm for course management at UCT.

Over the first decade of the 2000s, there were attempts to understand how well and to what extent technology was being integrated with teaching and learning. A 2008 study highlighted the challenges of large classes of students with varied abilities, resulting in the implementation of a range of teaching materials, such as interactive spreadsheets (Hodgkinson-Williams, 2008). The researchers explored the likelihood of open resource sharing to assist with the availability of teaching materials. Educators expressed interest but required assistance for implementation. Another 2008 study examined South African HEI students' use of computers for academic purposes. They found that while a small group of younger students acquired computer skills informally, the diversity of computer literacy skills in the participating sample indicated a clear role for the teaching of computer literacy in higher education (Brown, Czerniewicz & Pedersen, 2008:4).

From 2010 onwards, there was a shift towards providing a digitally-enhanced in-class experience.

In addition to the aforementioned Classroom Renewal Project, the Lecture Recording Project was piloted in 2012 at various teaching venues (UCT, 2017a). The aim was to equip large teaching venues with recording capabilities to encourage lecture recording. The recordings were uploaded to Vula for students to view. By 2017, 88 venues across campus were equipped with lecture recording capabilities (UCT, 2017a:1). To date, there are 91 lecture recording enabled venues across UCT (UCT, 2020).

A pilot Laptop Project from 2013 to 2016 provided over 243 first and second-year students on financial aid in specific courses with laptops (Chernotsky, Brown & Marquard, 2016:7). The laptops offered students increased mobility and more options in the learning process (Brown & Pallitt, 2014:47). It also gave educators opportunities to explore more feedback and engagement options (Chernotsky et al., 2016:14). From 2017, this initiative was centralised to ICTS, where over 800 first-year students on financial aid received laptops (Swingler, 2017).

The 2015-2017 period was strongly shaped by the institutional response to the national #FeesMustFall (previously #RhodesMustFall in 2015) protests. Shutdowns occurred for around two weeks towards the end of 2015 and again in 2016 (Davis, 2015; Etheridge, 2016). In 2016, shutdowns threatened the completion of the academic year (Etheridge, 2016). In response, the university instructed its faculties to provide "blended learning" (africanews, 2016; eNCA, 2015; Kekana, Isaacs & Corke, 2015). Of concern was students' access to resources which "further entrench the socio-economic inequalities" and "benefits those who own and control capital" (UCT SRC, 2016). Furthermore, the lack of experience with this mode of teaching among educators (Czerniewicz, Trotter & Haupt, 2019:62) suggested a lack of education technology integration.

Developments over 2015-2017 focused on increasing the flexibility of the academic project. This included the aforementioned Lecture Recording Project, which became the default in 2018 in abled venues with an opt-out option (UCT, 2017a:1). This service was previously demanded by students for 2017 (Newsroom, 2016).

By 2015, there was consensus amongst heads of departments that online education was part of the future of HEIs (Czerniewicz, Bot & Gordon, 2015:3). However, there were concerns around quality assurance and loss of interaction (Czerniewicz et al., 2015:16). There was a call for a policy framework to guide such endeavours (Czerniewicz et al., 2015:47).

Thus an Online Education Policy was adopted in 2017. It maintained UCT as a residential teaching institution and set limits to the proportion of online modules within the undergraduate curriculum (UCT, 2017b:3). Its goal was to provide innovative and renewed modes of teaching and learning to increase throughput and to cultivate critical thinking (UCT Council, 2016:9). This was done by encouraging staff to utilise education technology in their practices as well as providing online education (UCT Council, 2016:14). As such, the policy indicated the need for in-house capacity as "core knowledge and expertise related to all aspects of online education must reside within the university" (UCT, 2017b:6). As a result, a five-year Formal Online Education Project commenced in 2018, aimed at developing online and blended undergraduate courses as well as fully-online postgraduate programmes (CILT. n.d.-a).

To visually summarise UCT's technology integration over the years, Figure 1 provides a timeline of the events described above.

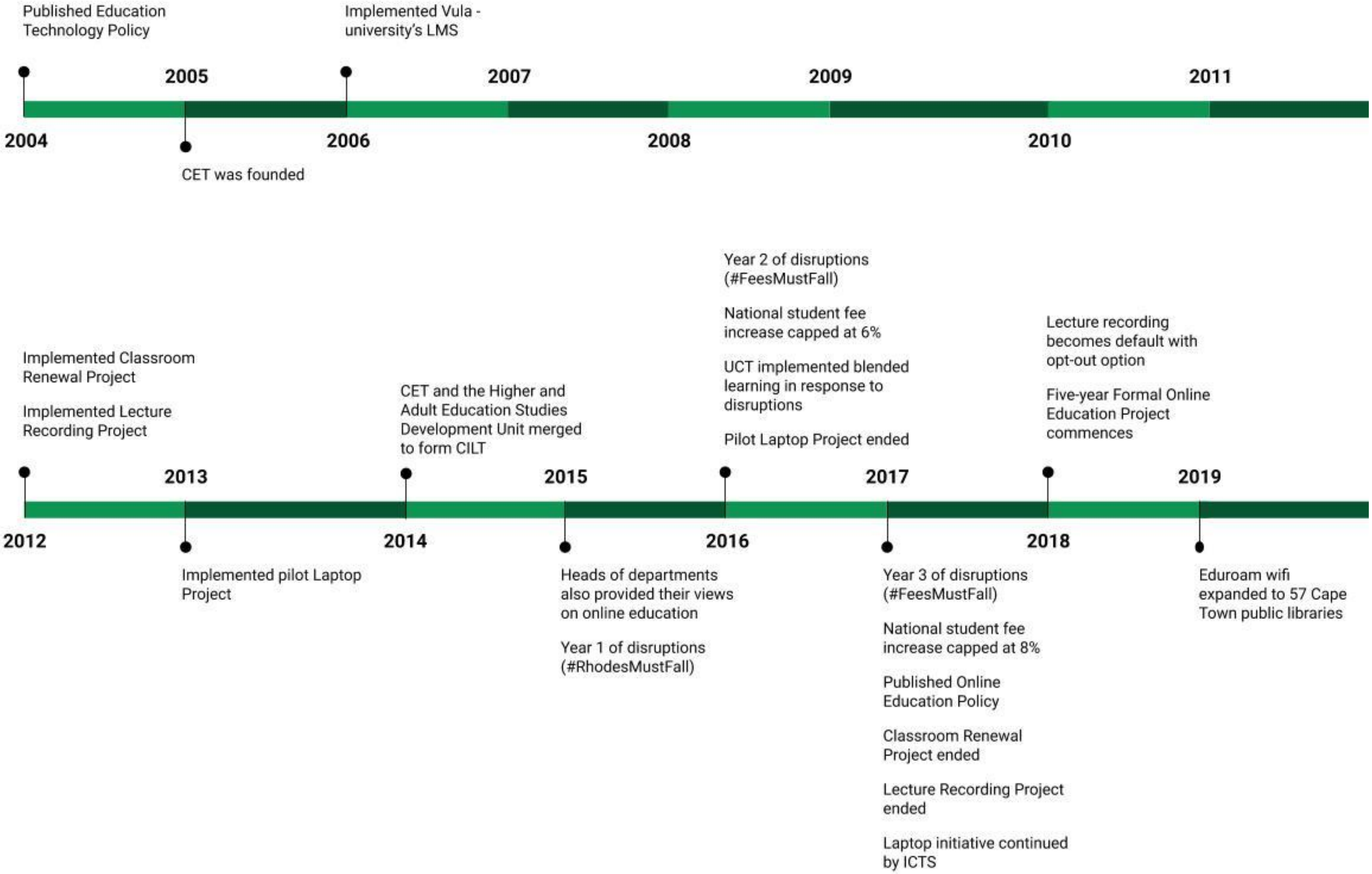


Figure 1: A timeline of events in UCT's technology integration process

2.2. The Engineering Faculty

This study is situated in a department within the Faculty of Engineering and the Built Environment (EBE) at UCT. This section introduces this faculty, and outlines its experiences with education technology in relation to the faculty's pedagogical approach.

UCT consists of six faculties. EBE was the third-largest in 2019, with 3 872 students. The faculty is made up of six departments and offers internationally-accredited degrees. EBE educators are active researchers and experts in their fields with ties to industry. EBE students enrol in courses in other faculties and are required to complete practicals in laboratories on campus.

Based on 2012-2017 annual teaching and learning reports, EBE reported minimal education technology endeavours, as none of the teaching and learning was explicitly online or blended. In 2013, two departments participated in the Laptop Project (Chernotsky et al., 2016:6). In 2015, they developed reports to monitor and analyse student data for throughput purposes (UCT, 2015:37). In 2016, EBE offered some non-credit-bearing postgraduate courses online (UCT, 2016:38).

During the #FeesMustFall period, EBE was unprepared for blended learning. Many educators use of Vula was limited to sharing documents and assignments, which failed to adequately support student learning. Additionally, students did not have access to on-campus facilities. This was problematic for the practical components in engineering where physical access to laboratories and specific equipment were required. The practical experience is imperative to the faculty's pedagogical approach as well as for accreditation purposes. It was also difficult to ensure meaningful interactions that fostered collaboration and team work among students (UCT, n.d.-a). This impeded the creation of an encouraging learning environment through "getting to know students personally, and by helping them to get to know each other and form good working relationships with one another" (UCT, n.d.-b). Lastly, staff were simply not trained to teach in this manner. To ensure the integrity of the academic project, EBE offered a mini face-to-face semester in January 2017, before the start of the academic year. The mini semester was fully attended and many were pleased with the outcomes (UCT, 2017).

EBE's struggle with blended learning presents an opportunity to improve teaching and learning practices from an education technology perspective. While remote teaching is generally not the goal of a contact university such as UCT, there is value in understanding how education technology integration may enhance the teaching and learning experience.

At the inception of this study, I was employed as an administrative member of staff at EBE. The nature of my position allowed me to interact with staff from all departments in the faculty, both educators and administrators. This helped to build relationships that would prove useful for a research project. As an administrative member of staff, I had little to no influence on teaching and learning at EBE. This meant I was in a position of relative neutrality when investigating a pedagogical topic. Thus, I was at suitable proximity to understand education technology integration in this context.

This chapter presented the relevant national, institutional and faculty context to set the stage for understanding education technology integration in my study. The next chapter will discuss the theoretical models and literature pertaining to education technology integration.

Chapter 3: Understanding and Researching Education Technology Integration

This chapter presents a definition of education technology integration, followed by a discussion of factors impacting on educational technology integration. Having sketched some of the concepts relevant to educational technology integration, I review an analytic framework – Cultural Historical Activity Theory, and outline how this provides a descriptive and analytic resource for investigating integration.

3.1. Defining Education Technology Integration

Education technology integration is a process of creating conditions for learning via technological tools (Ruggiero & Mong, 2015:168). This complex process requires thoughtful decision making in terms of the technological tool that is adopted (Buabeng-Andoh, 2012:137). Specifically, education technology integration requires learning the technology, using it for teaching and learning processes, and ensuring that it is integrated with teaching and learning activities to support student learning (Gorder, 2008:64). As a result, education technology integration represents a wholeness, where content and pedagogy are aligned with technology, while considering contextual factors (Buabeng-Andoh, 2012:137; Davies, Dean & Ball, 2013:576). Integration requires constant reflection to ensure suitability (Gorder, 2008:65; Ruggiero & Mong, 2015:174).

There is a difference between education technology use and integration. The former is achieved by the presence of technology, whereas the latter is able to attain instructional goals and provide authentic learning experiences (Ruggiero & Mong, 2015:169). Inan and Lowther (2010:138) found that technology integration in schools was presented in three categories. The first was technology as a learning tool for instructional purposes, either as delivery or preparation; the second for professional use by educators in classroom activities; and finally for student use via software applications.

Education technology integration has also been understood in relation to specific methods, such as blended learning and the flipped classroom. Both these approaches encourage students to be active learners and may redefine face-to-face time to clarify information or apply material (Davies et al., 2013:565). Georgina and Olson (2008:2) found blended learning to be the most successful approach to education technology integration. Davies et al. (2013:577) pointed out that the flipped classroom has scalability potential and noted that it was at least as effective as the traditional classroom.

The core component of education technology integration success is the educator (Gorder, 2008:73). Educators must be technically literate. This means that educators know how to use technology effectively to achieve learning goals (Davies, 2011:46; Gorder, 2008:65). In other words, such educators know what, when, and how to use technology to maximise student learning experiences (Davies, 2011:47). Ertmer (2005:25) noted that while computers served as an invaluable instructional tool, teachers must be given convenient access to them as well as autonomy to integrate such devices with the curriculum. A constructivist pedagogy should be encouraged among teachers (Ertmer, 2005:25; Gorder, 2008:64), as Ruggiero and Mong (2015:174) noted that student-directed learning is better suited to education technology integration efforts than teacher-directed learning.

Although these definitions are useful, education technology integration is highly dependent on context. This is particularly so as UCT faculties and departments have autonomy to enact their own understanding of education technology integration. Thus for this study, education technology integration definitions will serve as a guiding concept, however this research will focus specifically on the integration practices of UCT educators in one engineering department.

3.2. Achieving Education Technology Integration

The integration of educational technology is often described in terms of overcoming barriers. Ertmer (1999) offers two categories of barriers: first-order barriers which are obstacles **external** to educators, and second-order barriers, which are obstacles **intrinsic** to educators. Addressing these barriers is key to the successful and meaningful integration of educational technologies (Kim et al., 2013; Sherman & Howard, 2012). Ertmer's categorisation has been popularly used in the literature (e.g., Buabeng-Andoh, 2012; Kim et al., 2013; Sherman & Howard 2012; Tsai & Chai 2012), and in conjunction with other concepts, such as TPACK or TAM, provide a useful framework for thinking about the factors impacting on technology integration.

3.2.1. First-order Barriers

First-order barriers to integration such as physical infrastructure, time, training, technical support and institutional priorities, are external to educators (Ertmer, 1999:50). These barriers have often been the target of early interventions, and can be resolved with the allocation of resources (Ertmer, 1999:50). Additionally, despite the inconvenience caused by first-order barriers, they do not necessarily prevent teachers from integrating education technology in situations where second-order barriers are not present (Sherman & Howard, 2012:2103).

3.2.1.1. Physical Infrastructure

Physical infrastructure refers to device requirements, access, and connectivity. The quality of connectivity is especially important. Demir and Yurdugül (2015:258-2) consider the adequacy of technical infrastructure to include a stable network connection. The speed of connectivity is also pertinent, as low speeds lead to frustration, which ultimately contributes to user dropout (Demir & Yurdugül, 2015:258-2; Keramati, Afshari-Mofrad & Kamrani, 2011:1926). Reliability of infrastructure supports and enables a networked society that transcends geographical locations (Tarvid, 2008:16). This alludes to the need for information security as part of the infrastructural requirements (Keramati, et al., 2011:1920; Tarvid, 2008:22).

Georgina and Olson (2008:6) noted that, while it should be the institution's responsibility to set up such an infrastructure, consultations should be made with end-users to encourage ownership of the process. According to Chapter 2, UCT has adequate infrastructure, so this will not be a focus in this study.

3.2.1.2. Time and Technical Support

Integration of education technologies may result in increased workload, such as responding to student queries electronically, adapting to new technological tools, and maintenance associated with content and upgrades (Buabeng-Andoh, 2012:141). Without adjusting for the increased workload, educators may experience frustrations and resist integration. To overcome first-order barriers, support should be considered (Adeyelure & Kalema, 2019; Akaslan & Law, 2011:486; Garrison & Vaughan, 2013:19; Ying & Yang, 2017:3). Support could be technical, as equipment failure is frustrating, which impacts on willingness to use (Buabeng-Andoh, 2012:144).

There should be a committed effort to ensure fair allocation of support (Demir & Yurdugül, 2015:258-2; Pathiratne, 2014:163). On an organisational level, this may include administrative support, technical support, human resource support, and financial support (Demir & Yurdugül, 2015:258-2; Esterhuizen, Blignaut & Ellis, 2013:64). Technical support at UCT is provided by ICTS (hardware installation and support) and CILT (Vula helpdesk).

3.2.1.3. Leadership and Institutional Priorities

Leadership support has been found to be a strong predictor of use and thus education technology integration (Esterhuizen et al., 2013:64; Kiula, Waiganjo & Kihoro, 2017:101; Tarvid, 2008:21). Leaders who drive technological plans and possess a shared vision with staff encourage education technology integration (Buabeng-Andoh, 2012:144) and enable staff empowerment (Tondeur et al., 2011:141). Leaders who are involved in the process of formulation can align organisational goals and directives, thus stimulating more buy-in (Moskal, Dziuban & Hartman, 2013:16). Darab and Montazer (2011:908) found that employees were more open to e-learning when they felt that management was also in support of the idea. To promote e-learning in Africa, Unwin et al. (2010:7) suggested that the focus should shift from hard infrastructure to soft skills, such as management support and expertise development.

3.2.1.4. Training

In order to build knowledge, training should be provided to teaching staff (Machado, 2007:78; Ying & Yang, 2017:3), although this does not guarantee quality integration (Buabeng-Andoh, 2012:142). Training on appropriate knowledge should be offered by experts (Buabeng-Andoh, 2012:143). Demir and Yurdugül (2015:258-8) found that training increases staff's technical confidence, which encouraged them to explore other forms of relevant tools. They also found that those with an increased need for support perceived existing support as insufficient. This highlights the importance of the quality of existing training as well as compatibility with existing processes (Demir & Yurdugül, 2015:258-2).

Sherman and Howard (2012:2099) found that first-order barriers were prevalent in South African basic education. They noted issues surrounding technical competence, access to devices, insufficient technical support, and limited ICT training. UCT, as a tertiary education institution, presents a different picture as physical infrastructure is provided and CILT contributes to knowledge building by providing pedagogical support on learning technologies, course design, and staff development. Therefore contextually, UCT has little first-order barriers to overcome.

3.2.2. Second-order Barriers

Second-order barriers are elements **intrinsic** to educators that impact on educational technology integration, such as attitudes and beliefs, deeply tied to fundamental understandings of teaching and learning, teacher-student roles, and classroom practices (Ertmer, 1999:51).

The initial formulation of first and second-order barriers glosses over the impact of knowledge on educational technology integration with a few questions:

> "How does this software package work? Where or when should I use computers? ... How can I ensure that students obtain adequate computer time without missing other important content? How do I weave computers into current curricular demands?" (Ertmer, 1999: 48).

Kim et al. (2012:77) responds to this by locating "teacher knowledge (e.g., TPACK)", externally to teachers as a first-order barrier. Alternatively, Tsai and Chai (2012:1057) include teachers' pedagogical beliefs as second-order barriers, and propose a third-order barrier linked to design thinking. The close association between educators' knowledge and belief, suggests that knowledge may productively be considered a second-order barrier.

3.2.2.1. Attitudes towards Educational Technology Integration

An attitude is a learned, robust affective evaluation of something. It can be positive or negative (Onwuagboke & Singh, 2016:79). Teacher attitudes have been found to be a predictor of innovative education technology use (Buabeng-Andoh, 2012:138; Onwuagboke & Singh, 2016:80). Sherman and Howard (2012:2100) noted that teachers' beliefs regarding teaching and learning impacted on their choices of ICT to integrate into their classrooms.

The Technology Acceptance Model (TAM, Figure 2) is concerned with two categories of attitude towards using educational technologies: perceived usefulness and perceived ease of use (Chuttur, 2009:5). Perceived usefulness is the extent to which an individual believes that using the technology would improve their performance. Perceived ease of use is the extent to which an individual believes that using the technology is effortless, both mentally and physically. Perceived ease of use has been found to have an effect on perceived usefulness. Both these concepts are affected by external variables such as system design features, training needs, user input on system design, and user characteristics.

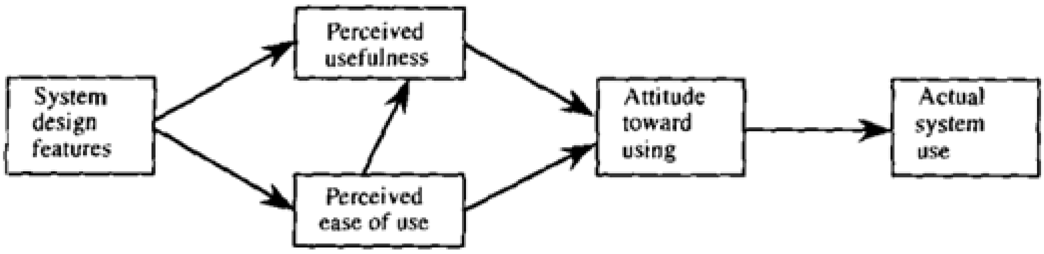


Figure 2: TAM (Chuttur, 2009:10)

Thereafter, TAM 2 was developed to explore determinants for perceived usefulness (Chuttur, 2009:14). Subsequently, TAM 3 expanded on TAM 2 to add antecedents for perceived ease of use (Venkatesh &

Bala, 2008:278). Perceived ease of use's antecedents pertains to an individuals' relationship with computers such as computer self-efficacy, perceptions of external control, and computer playfulness (Venkatesh & Bala, 2008:280).

Focusing on concepts such as subjective norm, technological complexity, and application self-efficacy from TAM 2, a quantitative study at a Turkish vocational college, examined the predictors of LMS use among educators (Cigdem & Topcu, 2015). Subjective norm is the perceived social pressure to perform a behaviour. Technological complexity is the perceived difficulty to use and comprehend the technology. Application self-efficacy is the level of technological self-confidence based on previous technological experiences. Viewed through the len of barriers, these second-order barriers positively correlated with behavioural intention.

Experience with computers has been found to have a positive effect on teachers' computer attitudes. This means that the more experienced teachers are with computers, the more likely they are to display positive attitudes towards them thus affecting the likelihood of integration (Buabeng-Andoh, 2012:138). In TAM 3, experience was found to decrease computer anxiety and playfulness overtime to impact individuals' perceived ease of use towards a technology (Venkatesh & Bala, 2008:278).

Another TAM 3 concept that affects perceived ease of use and integration behaviour is computer self-efficacy. It represents one's perceived confidence and internal locus of control in successfully utilising ICT for education purposes (Buabeng-Andoh, 2012:139). Computer self-efficacy affects teachers' beliefs about the value of technology as well as teaching and learning with technology. Ultimately, this impacts integration behaviour (Kim et al., 2013:77). Likewise, Sherman and Howard (2012:2100) noted that teachers' beliefs regarding teaching and learning impacted on their choices of ICT to integrate into their classrooms. Overcoming first-order barriers, such as providing time for experimentation with computers and proper training, can foster computer self-efficacy. As the fear of damaging devices decreases, internal locus of control regarding the device increases, thus developing computer self-efficacy (Buabeng-Andoh, 2012:139).

The majority of TAM's determinants focus on the individual, which, while providing a valuable language for individual experience, do not fully capture the communal or collective experience.

3.2.2.2. Knowledge and Educational Technology Integration

Knowledge for integration is to know how, when, and why to use a tool (Englund et al., 2017:73). Also known as computer competence, this is the ability to operate multiple computer applications to achieve various objectives (Buabeng-Andoh, 2012:139). Consistently, it has been found that a student-centred approach produces more successful integration than a teacher-centred approach (Englund et al., 2017:74). This is because the former re-evaluates the traditional authoritative position of a teacher, thus shifting the relative power and control in the classroom (Sherman & Howard, 2012:2104).

Developed by Koehler and Mishra in 2006, the Technological, Pedagogical and Content Knowledge (TPACK, Figure 3) framework addresses some of the gap related to knowledge in Ertmer's treatment of first and second-order barriers.

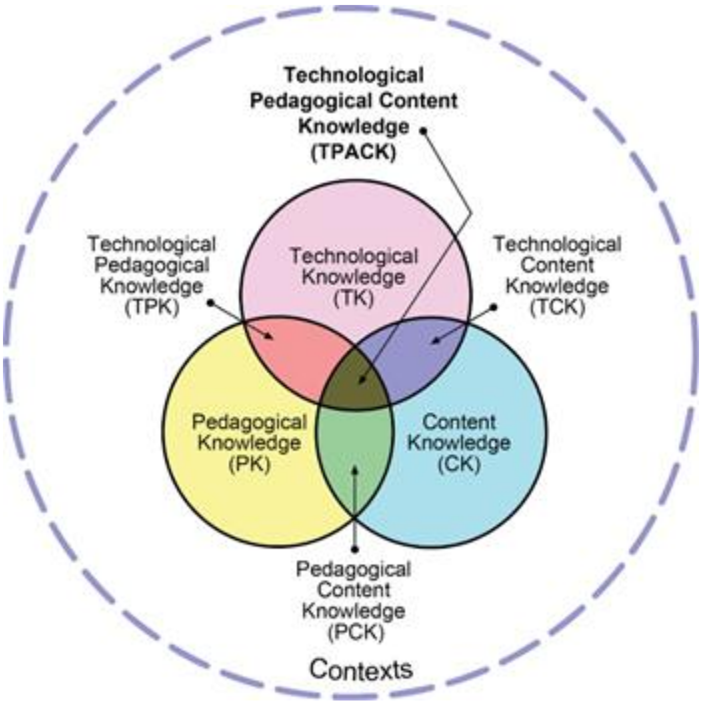


Figure 3: TPACK (Koehler & Mishra, 2009:63)

Each circle represents a type of knowledge (Koehler & Mishra, 2009):

- Content knowledge (CK): knowledge regarding the subject.
- Pedagogical knowledge (PK): knowledge of teaching and learning practices.
- Technological knowledge (TK): knowledge for which technological tools are suitable to attain prescribed goals. Conclusions made from this knowledge are not fixed due to changing technological tools.

The overlapping sections of the circles represent additional types of knowledge (Koehler & Mishra, 2009):

- Technological pedagogical knowledge (TPK): knowledge regarding the teaching and learning practices that particular technologies can afford.
- Technological content knowledge (TCK): knowledge regarding the appropriate technology to adopt to convey a particular subject.

- Pedagogical content knowledge (PCK): knowledge regarding the appropriate teaching and learning practices to use for a particular subject.
- Technological pedagogical content knowledge (TPACK): knowledge and conclusions acquired from the interplay between content, technology, and pedagogy.

Educators with TPACK know, to varying degrees, how content is represented by technology, how pedagogies that utilise technology convey content, how technology simplifies content, and what constraints students face when learning in both online and face-to-face spaces (Koehler & Mishra, 2009:66).

Jaikaran-Doe and Doe (2015) examined engineering educators' TPACK at an Australian university via survey. The survey was conducted on in-service educators at the university and pre-service educators at another university in order to compare the level of TPACK. They found that in-service educators had lower levels of TPACK than pre-service educators (Jaikaran-Doe & Doe, 2015:164). However, they were unable to determine why, as they could not provide an assessment of TPK and TCK among educators. This problem was reflected in other studies (Jaikaran-Doe & Doe, 2015:164). This may point to possible construct concerns regarding the framework.

Jwaid, Clark and Ireson (2014) used TPACK to develop an approach to teach process control at the university level. They aligned process control elements such as industry, technology, and pedagogy to the TPACK framework. Feedback was obtained via student interviews. However, the number of interviews was not disclosed, and as such it was unclear whether this was a representative sample. When substantiating their findings, they quoted feedback from a single student. Thus, it was difficult to determine whether their approach to process control was beneficial.

One of the major concerns with TPACK is the definition of PCK and how to distinguish it from the other constructs. This permeates into operationalisation exacerbated by TPACK's complexity when other constructs are considered (Graham, 2011:1960). This also blurs the distinction between concepts complicating the construction of valid instruments (Graham, 2011:1969).

However, in conjunction with TAM, and the analytic framework I propose in the following section, TPACK may serve as a mediating tool to understand the choices of technologies among educators.

3.3. Investigating Education Technology Integration

As discussed in Chapter 2, UCT has engaged with education technology with the protest period revealing various shortcomings that justifies the need to further understand education technology integration at the university. First and second order barriers provide useful guides but the specifics would depend on context. Thus a theory that considers context would be useful in this study. Hence the Cultural Historical Activity Theory (CHAT) was the selected theory to investigate education technology integration in this study. This section presents CHAT, some example studies and its suitability for this study.

3.3.1. Cultural Historical Activity Theory

Activity theory is the foundation for CHAT (Yamagata-Lynch, 2010:22). CHAT investigates an activity in a social context. This is known as an activity system (Yamagata-Lynch, 2010:22). The elements in an activity system (discussed below) must be explored to understand the activity.

3.3.1.1. First Generation

In the early 20th century, Vygotsky introduced the concept of mediated action, which is the interaction between an individual, and mediating artefacts. He believed that human engagement with the environment is indirect, i.e., not stimuli-driven. Rather, it is mediated via tools and signs (Engeström, 1999:1; Igira & Gregory, 2009:435). Signs are not tangible; they are merely a by-product of the interaction between the individual and the mediating artefact (Yamagata-Lynch, 2010:16). The semiotic process of mediated action is presented in Figure 4.

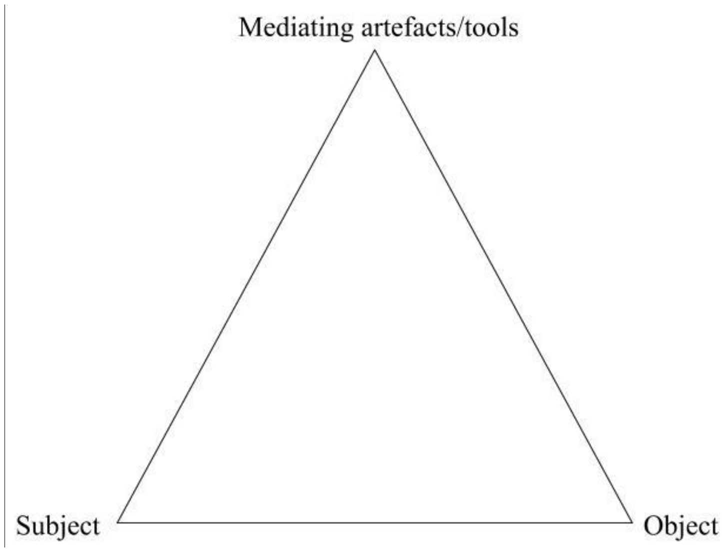


Figure 4: Vygotsky's mediated triangle

The *subject* is an individual or individuals engaged in an activity (Igira & Gregory, 2009:436; Yamagata-Lynch, 2010:16). *Mediating artefact/tools* can be physical (e.g., technical tools) or psychological (e.g., previously gained knowledge), all of which contribute to the mediated action

(Gedera & Williams, 2015:154). Mediated action enables the subject to transform the object based on the limitations of the tools (Igira & Gregory, 2009:436). The *object* is the goal of the activity. The object holds the activity and its components together. It also implies individuals' or groups' motivation to pursue an activity (Yamagata-Lynch, 2010:17).

The mediated action triangle is not a fixed state, and individuals are not passive in the process (Igira & Gregory, 2009:436; Yamagata-Lynch, 2010:16). This opposes the dominant view of individuals as being governed by imposed stimuli. This is evident in the use of signs whereby the subject may transform them into artefacts or cultural tools. Although it is unclear when this occurs, the transformation is indicative of its perceived value by the subject for the activity (Yamagata-Lynch, 2010:17). This transformation process denotes an element of agency. Furthermore, signs can materialise at any point and be incorporated into the activity, thus supporting the variability of the mediated action triangle.

3.3.1.2. Second Generation and Beyond

Leontiev and Luria evolved Vygotsky's mediated action from a single process to a string of processes in a bounded system (Yamagata-Lynch, 2010). Their concept of object-oriented activity understands the development of consciousness as self-regulated. Meaning is made through achieving goals based on the motives of individuals or groups. Thus, it allows the exploration of the psychological via observable behaviour. Furthermore, experiences and events within the activity may also change the subject, their environment, their motives, or even the activity itself. However, a goal-directed action is not the same as an object-oriented activity. The former is temporary and does not significantly impact the collective. Goal-directed actions contribute to or modify an object-oriented activity (Yamagata-Lynch, 2010:21).

Engeström expanded on Leontiev and Luria's work by providing an analytical method for understanding activity systems. He developed CHAT, as it is widely used today. Engeström's activity system (Figure 5) consists of the individual, their colleagues, and the cognitive and physical tools used, rules that dictate behaviour, as well as the objective of the work (Engeström, 1999:2; Hashim & Jones, 2007:7).

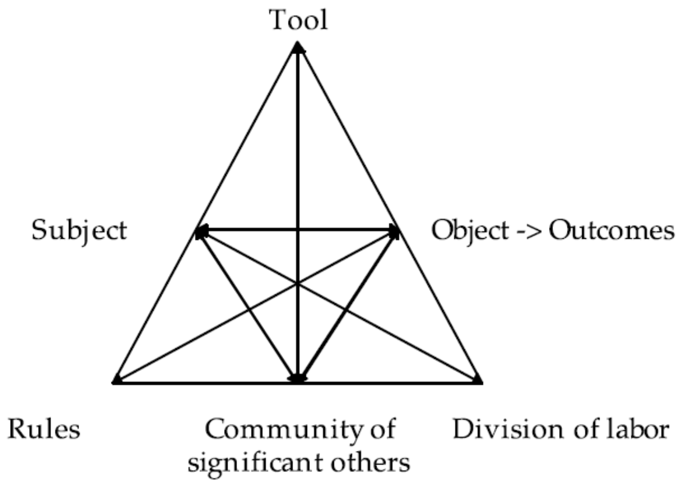


Figure 5: Engeström's activity system (Foot, 2014:332)

The nodes in the activity system are explained below (Foot, 2014:331; Hashim & Jones, 2007:5; Igira & Gregory, 2009:438; Sannino & Engeström, 2018:45; Yamagata-Lynch, 2010:22):

- The *object* is the aim of the activity. It has three characteristics: requires actioning, has motive, and has desired *outcomes* (Foot, 2014:334). However, depending on the particular activity system under examination, objects may differ (or be shared), by different people in the same context. Therefore, the object should be identified first when using CHAT for research purposes.
- The *subject* is the individual or group of individuals trying to achieve the object.
- *Mediating tools* can be physical or psychological tools that serve the object. Psychological tools are accessed through social interaction and transforms mental functions (Gedera & Williams, 2015:154). It may "include artefacts, social others, and prior knowledge that contribute to the subject's mediated action experiences within the activity" (Yamagata-Lynch, 2010:16). Over time, subjects internalise psychological tools into their unconsciousness (Gedera & Williams, 2015:155).
- The bottom nodes are indicative of the socio-historical aspect of this theory.
    - *Rules and norms* represent formal and informal regulations that guide the subject's behaviour to attain the object.
    - *Community* involves groups that the subject belongs to when pursuing the object.
    - *Division of labour* shows the horizontal distribution of responsibility as well as alludes to the vertical power structures in the community.

The top triangle is based on Vygotsky's original mediated-action triangle. The interconnectedness of the diagram demonstrates how components influence each other in the activity system. For example, rules mediate the relationship between the subject and the community. Likewise, divisions of labour mediate the relationship between the community and the object (Hashim & Jones, 2007:6). This interconnectedness means that the object is always mediated by the various nodes in the system (Lee, 2011:407).

Engeström allowed for greater understanding of activity systems by observing human behaviour in the various components (Hashim & Jones, 2007:6). The addition of macro-level components places equal emphasis on the environment and the subject. Furthermore, this version emphasises the socio-historical aspect of the various components in the activity system. This means that, to fully understand an activity system, one must examine the development of the system, thus highlighting the notion of historicity (Sannino & Engeström, 2018:46). This results in a context-bound, highly-descriptive, and time-relevant understanding of a particular activity (Nussbaumer, 2012:45). Multiple perspectives are advised to understand an activity system; hence a qualitative approach is recommended (Foot, 2014:330). This was echoed by Lee (2011:410) who noted that CHAT is best used in small-scale, educator-oriented studies with an interpretive approach.

Engeström further developed the change laboratory process as an intervention from CHAT (Nussbaumer, 2012:39). The change laboratory process utilises contradictions in order to evolve the activity system. Contradictions are emergent disturbances in the activity system necessary for change and the development of the activity system. Subjects grapple with and resolve contradictions in order to form a new equilibrate activity system (Lim & Hang, 2003:52).

3.3.1.3. CHAT Examples

CHAT's ability to embrace complexity makes it a suitable theory to examine practical educational problems (Lee, 2011:413).

Studies that utilise CHAT often provide in-depth contextual descriptions of the activity system. The description can, at times, extend beyond the immediate activity system to its broader socio-historical context. Nhu, Keong and Wah (2018:25) identified challenges to ICT use in schools due to limited availability and inadequate support. They highlighted the interconnectedness of CHAT, whereby socio-historical context, such as national changes, impacts the activity system. Lim and Hang (2003:55) also indicated influence from the wider context, whereby school integration plans were cognisant of the Ministry of Education's deadline (Lim & Hang, 2003:56). This resulted in integration that was aligned not only to the school's needs, but also to broader national education objectives.

Furthermore, historicity allowed Lim and Hang (2003:60) to trace how ICTs were integrated over time. They noted that, initially, technologies were added on to the existing classroom activities. Over time, integration evolved to incorporate interactive components in the classroom. In Lee's (2011:411) curriculum development study at a Singapore school, CHAT's socio-historical consideration captured the curriculum's origins and development at the school level as well as the national policy-making level. Conversely, a snapshot of a dynamic activity system can help one to understand human behaviour and pedagogy in a particular context in time (Batiibwe, 2019:16).

CHAT's emphasis on complexity allows one to recognise various objects and outcomes. Lee (2011:411) noticed that many supported the new curriculum, but their motivations differed. Likewise, Lazarou (2011:430), studying the use of a simulation-based science education game, noted that there were different anticipated outcomes between students, who believed that learning should be entertaining, and teachers, who used technology to achieve curriculum objectives. CHAT was able to capture the difference in anticipated outcomes between the teachers (curriculum objectives) and the students (fun learning experience).

Richer data is a by-product of CHAT's complexity. This helps to unpack the concept understudy in one's research context (Koszalka & Wu, 2004:500). A case study found that CHAT's nodes enabled a richer understanding of context, which led to teachers' integration of space science resources (Koszalka & Wu, 2004:499). When employed overtime, CHAT has the ability to understand the evolution of processes. Such as Anthony (2011:341), who found that teachers' technology use was supported by changes in planning and integration systems over a three-year period.

Considering education technology integration as a process, exploration of socio-historical (i.e., contextual) nodes may assist with understanding the development of current integration practices.

3.3.1.4. CHAT and This Study

My interest is analytical, as I want to understand educational technology integration in the teaching practices of an engineering department. Thus, the most suitable approach is to employ second-generation CHAT to explore the problem. Mapping the activity system of the department would be an excellent method to ensure that all necessary influential elements are considered, should further attempts of technology-mediated learning be pursued. Although tensions may emerge from the data that allude to possible contradictions, my goal is descriptive and not implementation, thus these will not be the focus of this research.

Foot (2014:330) identified three core ideas of activity theory. Firstly, "humans act collectively, learn by doing, and communicate in and via their actions". This means that, when one is using CHAT, observable behaviour, or the expression thereof, is the manner in which data will be collated. This is suitable for this study, as I would like to describe the experiences of my participants with educational technology to understand their integration efforts. Secondly, “humans make, employ, and adapt tools of all kinds to learn and communicate”. Recognising that tools may be adapted suggests the various ways in which people respond to the environment. This captures creative solutions and adaptations exhibited in the engineering department. Lastly, “community is central to the process of making and interpreting meaning and thus to all forms of learning, communicating, and acting”. A department is part of a larger community, as it falls under a particular UCT faculty, and UCT falls under the community of tertiary institutions under the Department of Higher Education and Training in South Africa. These various community layers all impact one another. For example, the introduction of default lecture recording at UCT impacts on departments’ teaching and learning practices. CHAT allows one to inspect these various community layers and their influences, demonstrating its ability to explore detail as well as the bigger picture.

Engeström’s (1999:3) principle of multivoicedness allows one to explore a community’s various points of view. Historicity notes the importance of the historical context of an activity (Engeström, 1999:3; Sannino & Engeström, 2018:46). These concepts can help to understand the impact of changes in an environment. For example, a consequence of the protests was increased pressure to record lectures, including the adoption of an “opt-out” model. This decision may impact how students learn and how educators reflect on their teaching practices. Historicity and multivoicedness can capture and understand this change. By reflecting on these experiences and the remnants of such efforts, I can begin to understand education technology integration in the department.

The cultural nature of the environment that I am investigating is highly pertinent; CHAT enables the consideration of precipitating contextual factors, allowing for a deeper analysis through its various nodes (Foot, 2014:330). The activity system as a unit of analysis allows me to examine education technology integration at UCT amidst concerns, such as student access to electronic resources. CHAT enables me to capture the complexity of these concerns (Foot, 2014:330). It is also focused on people in the activity system (Foot, 2014:331), thus aiding in an investigation into education technology integration on an individual as well as departmental level.

3.4. Using Theory in This Study

Second-generation CHAT will be utilised as the overarching theory for this study. This is because it presents a holistic picture while acknowledging the interconnectedness of various elements that make up an activity system. Thus, this study will map out individuals’ and the department’s activity systems on education technology integration.

To synthesise CHAT and concepts from the literature, Table 1 lists the CHAT nodes and maps the concepts from the literature to the relevant node. It is unlikely that all elements from the diagram will emerge from the data. Likewise, aspects not on the diagram may emerge from the data. Therefore, this activity system will be used to assist with data analysis, but it is not a conceptual model of the study.

Table 1: CHAT Nodes and Relevant Concepts from the Literature

CHAT Nodes	Relevant Concepts from the Literature
Subject (educators)	• TAM - computer self-efficacy, computer anxiety, computer playfulness etc. (Chuttur, 2009) • Attitudes and beliefs (Kim et al., 2013)
Outcomes from object (education technology integration)	• Effective student learning (Buabeng-Andoh, 2012)

Mediating tools	• Infrastructure
	  o Access (Ertmer, 2005)
	  o Appropriate technology (Buabeng-Andoh, 2012; Demir & Yurdugül, 2015; Georgina & Olson, 2008; Keramati et al., 2011; Pathiratne, 2014; Tarvid, 2008; Tondeur et al., 2011; Unwin et al., 2010)
	  o Speed of connectivity (Demir & Yurdugül, 2015; Keramati, et al., 2011)
	  o Information security (Keramati, et al., 2011; Tarvid, 2008)
	  o Technical support (Buabeng-Andoh, 2012)
	• TPACK (Graham, 2011; Harris et al., 2009)
	• Prior knowledge (Yamagata-Lynch, 2010)
	  o Technical literacy (Davies, 2011; Gorder, 2008) / computer competence (Buabeng-Andoh, 2012)
	• Training (Ertmer, 2005; Machado, 2007)
	  o Experiential learning (Garrison & Vaughan, 2013)
	  o Student centred approach (Englund et al., 2017)

Community	• Networked society (Tarvid, 2008) • University - end users, management/leaders (Esterhuizen et al., 2013; Kiula, et al., 2017; Tarvid, 2008) • Support staff e.g., technical, human resource (Demir & Yurdugül, 2015; Esterhuizen et al., 2013)
Division of labour	• University to set up infrastructure (Georgina & Olson, 2008) • Increased workload for educators (Buabeng-Andoh, 2012) • Sustained collaborative leadership (Garrison & Vaughan, 2013) • Supportive leadership (Esterhuizen et al., 2013; Kiula, et al., 2017; Tarvid, 2008) • Encourage a shared vision with staff (Buabeng-Andoh, 2012)
Rules and norms	• Autonomy (Ertmer, 2005) • Management buy-in (Darab & Montazer, 2011) • Fair allocation of support (Demir & Yurdugül, 2015; Pathiratne, 2014)

The subjects will be the educators in the sample. The object is the concept of interest under study, i.e., education technology integration. This leads to effective student learning as an outcome. Second-order

barriers such as educators' attitudes and beliefs towards computers and technology may impact on integration.
Mediating tools consist of infrastructure, TPACK, prior knowledge, and training. Infrastructure is akin to first-order barriers. There are pre-existing practices of education technology integration at UCT, thus TPACK may assist with the interpretation of the object. Prior knowledge and training services both correspond to the definition of mediating tools.

The rest are contextual nodes. Groups listed under community are parties that impact education technology integration. Rules and norms associated with education technology integration from the literature are presented. The division of labour touches on leadership practices.

Note that information presented under the bottom three nodes are possible elements. An expansion of these nodes will occur during data analysis, as contextual nodes are highly dependent on responses from the sample, seeing as they pertain to the institutional level, e.g., leadership/management elements and support structures. Depending on their positions in the department, participants may not have the institutional level knowledge that would speak to these elements. Furthermore, the prevalence of institutional level elements in the above activity system highlights the need to investigate individual or departmental level education technology integration, particularly among these three nodes.

Having considered the literature and theories relevant to my research above, I will present the methodology of this study in the following chapter.

Chapter 4: Methodology

Thus far, I have introduced the study, provided an overview of the education technology integration, and presented the selected theoretical framework of CHAT, and supplementary concepts that assist with data analysis. This chapter will outline the research orientation, type of research, and research approach. Thereafter, it will look at the selection of participants, the data generation process - which will be broken down into collection and management, and analysis, along with ethical considerations. Finally, quality in qualitative research will be discussed.

The focus of my research is on engineering educators' experiences of integrating education technology into their teaching practice. The research questions are:

- What education technologies have been integrated by engineering educators?
- Why do engineering educators integrate education technology?
- What conditions enable engineering educators' education technology integration?
- What conditions constrain engineering educators' education technology integration?

With reference to CHAT, the first research question will elicit mediating tools/artefacts that the subjects adopted to attain the object of education technology integration. The second research question explores the outcomes of the object among the subjects. The last two research questions would provide insight into the contextual nodes of division of labour, community, and rules and norms.

4.1. An Interpretivist Approach

This study adopts an interpretivist approach to explore the integration of educational technologies into teaching and learning. To understand interpretivism, it is important to consider its ontological, epistemological, and methodological assumptions.

Ontology is the manner in which reality is perceived or understood (Creswell, 2009:6). Interpretivists believe that reality is socially constructed. As such, it is subjective, varied, and dynamic, as it may differ from person to person. This can be contrasted with a realist ontology, in which social reality is understood as objective, external from the individual, and therefore observable by the researcher (Cohen, Manion & Morrison, 2013). Compared to positivism, interpretivism understands that individuals' assumptions, circumstances, and experiences contribute to the construction of reality (Cohen et al., 2013:21). This means that individuals have agency in making meaning of the world. Therefore, the understanding of reality is fluid and may evolve as reality is affected by context (Cohen et al., 2013:20).

As a result, interpretivism is concerned with "situated activities" that are unique and non-generalisable (Cohen et al., 2013:20).

Epistemology is concerned with the production and acceptance of knowledge (Blair, 2016:50). For interpretivism, knowledge is produced through social constructions rather than objectivity. Thus, the context of social phenomena and the motivations behind actions are of interest to interpretivists (Cohen et al., 2013:21). Interpretivist research values the natural order; thick descriptions are needed in order to capture the social world (Cohen et al., 2013:20). As a researcher, the interpretivist likely has prior knowledge of the context (Cohen et al., 2013:33). While this may prove helpful, the researcher should ensure that the creation of knowledge is rooted in participants' experiences.

Interpretivist research methodology is qualitative (Cohen et al., 2013:21). Qualitative research is able to fulfil particular intellectual goals, such as understanding how participants make meaning of their experiences and the context in which they are situated (Maxwell, 2009:221). Considering the recent developments at UCT, CHAT's historicity would be useful here, as it is able to present activity systems as creations over time with varied backdrops.

Maxwell (2009:222) pointed out that qualitative research is able to address various practical goals, for instance, providing comprehensible results and theories that reflect participants' experiences and contexts. It produces formative studies that aim to improve current practices, as opposed to determining the results of current practices (Maxwell, 2009:222). My study attempts to contribute towards education technology integration in engineering by understanding its recent instances at UCT. Due to the use of CHAT and its holistic approach to an activity system, data collected is steeped in the experiences and contexts of the participants.

Qualitative research may create conditions in which participants are empowered to collaborate in the research process. (Maxwell, 2009:222). For example, during data collection, through reflection upon their education technology integration efforts, some participants concluded that things needed to be done differently.

Qualitative research has the ability to elicit rich data that is meaningful to the participants in their context (Cohen et al., 2013:461). Via a qualitative approach, I was able to gain insight into the participants' beliefs surrounding teaching with technology as well as their perceived experience of this mode of teaching. The concern of qualitative research is with processes rather than results (Cohen et al., 2013:461). As such, I was interested in participants' experiences with technology so as to understand education technology integration processes, rather than ascertain their effectiveness.

4.2. Case Study Approach

Merriam defines a case as “a thing, a single entity, a unit around which there are boundaries” (Merriam, 1998:27). Case studies are particularistic, focusing on a specific situation or phenomenon. They are descriptive, providing a rich description of the situation or phenomenon. Case studies are “heuristic” (Merriam, 1998:27), as in, they should help us understand the situation and phenomenon being studied.

Case studies offer a number of advantages (Cohen et al., 2013:256). They are rooted in reality. They allow us to reflect on complexity in the world. This enables researchers to use case studies to capture unique or conflicting information in the data which may be lost in large scale data collection, e.g., surveys. Case studies can be made readable for multiple audiences. This contributes to the democratisation of knowledge, as readers determine whether the results could be generalised to their situation.

Conventional generalisability is discouraged with case studies. This is due to the deeply contextual nature of the case study. Yet, this also makes case studies difficult to cross-check (Cohen et al., 2013:256).

A case study approach helped to explore the integration of educational technology into the teaching practices of a group of UCT engineering educators in a department. Although there is a rich field of research on engineering educators and education, there is very little on the integration of education technology among a connected group of educators in a HE context, in a developing world. The focus of this study was to describe, through a CHAT lens, the integration of educational technology. As my research was located within a specific department in the university, this social unit of analysis was considered as the selected case per Merriam’s (1998:27) definition.

For this study, the activity system of a department provided a boundary to analysis. It was focused on a specific phenomenon, namely education technology integration – the object of the activity. Like a case study, the derivation of the activity system required rich description, particularly into the context. This was achieved via the contextual nodes of community, division of labour, and rules and norms.

The use of one engineering department denotes this as a single case study where the participants (educators) are subunits (Merriam & Tisdell, 2016:40). Yin (2006:39) described a single case as one that should be unique, extreme, or critical. The selected engineering department was one of six in the faculty. Participants from this department showed a keen interest in the pedagogical aspect of engineering. This was the only engineering department in the faculty which had research areas in both engineering education and academic development. The coordinator of the faculty’s extended degree programme was based in this department. Additionally, the university established a research group which focused on engineering education matters in South Africa. Almost half of the members in this engineering education research group were from the selected engineering department at the time of this research. This is not to say other departments in the faculty did not display interest. Rather, there is a clear pedagogical interest at the heart of this particular engineering department, making it a unique single case.

The researcher plays an extensive role in the research process in qualitative case studies; they should be responsible for data collection and analysis (Merriam & Tisdell, 2016:37). There were many advantages to collecting the data myself. My experience as a student and staff member in the engineering department at UCT meant I was familiar with the assumptions, circumstances, and experiences of the participants; hence I was better able to understand their context. I had also previously-established rapport with potential participants and access to insider information. Furthermore, it was my intention to contribute to the pedagogical knowledge of the faculty.

4.3. Participants and Data

4.3.1. Selection of Participants

In order to ensure the selection was completed ethically, one should distinguish between ethical clearance and ethical deliberation. According to the Faculty of Humanities research ethics guide, the former refers to a review of the proposed research methods by an institutional committee, whereas the latter concerns continuous ethical discussions at various stages in the research process (Faculty of Humanities, 2016:7). In my case, a blend of the two was used to address the possibility of institutional harm in this study. Regular ethical deliberations with my supervisors (Faculty of Humanities, 2016:8) were done during the data collection and data analysis phases. Prior to data collection, I requested ethical clearance (see Appendix 1) from the School of Education at UCT. I also sought permission from the Human Resources department at the university to collect data from staff.

Thereafter, I approached a department within EBE. The selected department was one of the bigger departments (out of six) in the faculty. The educators' complement was varied, as there were staff at various levels of rank, from junior lecturer to full professors. I approached the Head of Department (HOD) to obtain authorisation to contact their educators for research purposes. The HOD agreed and subsequently provided a list of educators as potential participants. The educators from the list were approached for participation. In addition, an invitation was sent out via email to all teaching staff in the department.

Ultimately, five educators from the HOD's list participated, with three additional participants recruited via invitation. This sample (*n* = 8) amounted to 31% of the educators, as the department had a total of 26 educators (see Table 2). Only one participant was female. The sample spanned all educator levels available in the department; thus, participants were broadly represented across categories.

Table 2: Descriptives of Sample

Educator Title	**Department Descriptives**			**Sample Descriptives**		
	Male	Female	Total	Male	Female	Total
Professor	5	1	6	2	-	2
Associate Professor	5	-	5	2	-	2
Senior Lecturer	7	4	11	3	-	3
Lecturer	3	1	4	-	1	1
Total	20	6	**26**	7	1	**8**

All participants taught undergraduate courses and had varied experiences with supervision. This reflected in the data collection where it focused on the undergraduate space. Furthermore, half the sample had experience outside of HEIs.

4.3.2. Data Collection and Management

Participants who responded positively to the research invitation were contacted via email to set up a time and location for the interview. They were also supplied with a copy of the consent form (see Appendix 2) to peruse before the interview. The venue for the interview was suggested by the participant. This was either at their office or a departmental meeting room. If the latter, I booked a room via the department administrator.

Thereafter, each participant took part in an audio-recorded, semi-structured interview that lasted no more than one hour. In order to ensure truthful responses, it was important to build rapport with participants (Cohen et al., 2013:362). I believed that my experience at EBE assisted in establishing a baseline level of rapport. As a servicing officer on faculty committees, I had previously interacted with these participants. As a postgraduate examinations' administrator, integrity was required in order to ensure confidentiality in the examination process. I presume that my performance in these roles established trust prior to the interview process.

Rapport was achieved partly by the semi-structured element, keeping the interview conversational. The relatively open-ended nature also allowed for the exploration of interesting topics that came up (Cohen et al., 2013:353). The interview schedule (see Appendix 3) shows that the topic under research was introduced, followed by guiding questions along with possible prompts and/or probes (Cohen et al., 2013:361). The link between the research questions, the CHAT nodes and the interview questions are shown in Appendix 3.

At the interview, I began with an introduction and explained my background as a student and member of the support staff. Participants were informed of the purpose of the study and that the interview was confidential. I explained that, in order to ensure confidentiality, the interview would be transcribed with identifying information anonymised. Ensuring confidentiality helped to establish rapport and encouraged truthful responses from participants (Wilkie, 2015).

It is important to create an environment of trust, respect, and free from harm to ensure truthful responses are elicited in interviews (Kvale, 2007:8). Thus, I made sure to obtain informed consent. The consent form, previously emailed to participants, was provided as a hardcopy in the interview. During this process, participants were informed of the details of the research and the opportunity to withdraw. Before signing the consent form, I checked whether there were any questions from participants.

Thereafter, the data collection portion of the interview began per the interview schedule. I assured participants that all responses were welcomed without judgement as the focus was on their experiences. I took care not to interrupt participants' responses, but to listen actively to acknowledge and encourage the participants (Cohen et al., 2013:364). Being reflective as well as self-aware during the data collection process helped to reduce personal biases of the researcher (Wilkie, 2015). Therefore, I followed up only for clarification purposes and summarised participants' responses to ascertain my understanding.

Upon completion, the participant was thanked and the audio copy was made available to them within 24 hours should they wish to withhold any of the experiences shared during the interview or provide additional feedback. None of the participants indicated that they wished to withhold data shared in their interviews and no feedback was received.

In addition to interviews, records regarding educational technology use within the university and the department were gathered. These included, but were not limited to, information found on the UCT websites, policy documents, personal communications, etc. Such records were used to provide context in Chapter 2.

Anonymity is the assurance that data could never be traced to the identity of the participant, whereas confidentiality is where the researcher codes the data to conceal the identity of participants (Kvale, 2007:7). Anonymity is not a viable option for this research for two reasons. Firstly, I focused on one department where participants interact with each other. Thus, they may divulge their participation to their colleagues. Secondly, my presence and interactions with staff as interviews were conducted may have inspired speculation about participants' identities. Thus, my goal was to ensure confidentiality, particularly from external parties.

It is important to note that education technology integration was a contested subject at the university at the time of these interviews, catalysed by the #FeesMustFall protests. It was seen, by some members of the university community, as perpetuating the inequalities of access to knowledge. Because of the subject's contentious undertones, I have a duty to ensure the safety of my participants by securing confidentiality to the best of my abilities.

In order to ensure confidentiality, all data was securely stored on Google Drive with a two-step authentication process. Transcribed interviews were also coded to remove any identifying information. Only my supervisors and I had access to the transcribed data and recordings.

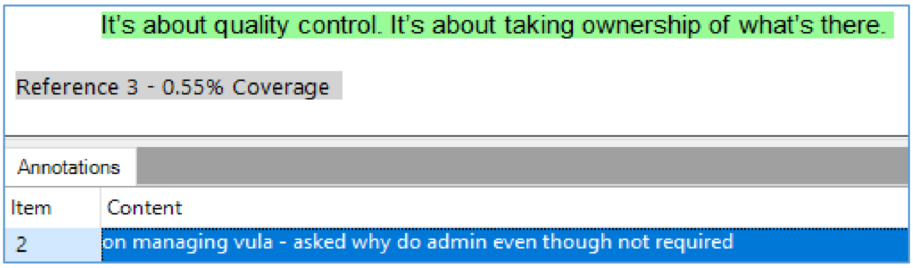
To ensure confidentiality in the write-up process, I took care not to mention the department name, course names taught by participants, specific programme details, nor groups participants belonged to. These are all potential clues that may allude to the participants' true identities, particularly when read by a close party to the department. This also meant that the transcriptions would not be shared publicly.

4.4. Data Analysis

The act of transcription served as a reflective exercise, challenging me to engage constantly with the data to ensure that my understanding was free from personal bias.

Each transcribed interview was analysed thematically according to the nodes in the selected theoretical model (CHAT). This was done first on an individual level to establish individual activity systems:

1. For each interview, all relevant data, regardless of its relation to education technology integration, was coded according to the CHAT nodes in NVivo 12 Pro. The Annotation function was used to note down thoughts and possible categorisation within the nodes.
   For example, below is a piece of data that was coded into the division of labour node on NVivo 12 Pro. The participant spoke about taking on administrative duties that were not required of educators in the department. Thus, an Annotation was added to provide this context which will help in the writeup process.



2. Coded data was extracted from NVivo into MS Word. This was done for each CHAT node.
3. I re-analysed the data to ensure it belonged in the coded CHAT node. This was done by referring to the CHAT node definitions and rereading the data under each CHAT node (MS Word files).
4. Data deemed unrelated to education technology integration was ignored.

Various approaches to the individual activity systems were presented to my supervisors for feedback before a format was agreed upon for write-ups. The format was such that each educator's activity system was to be presented with subheadings for each CHAT node. The same would be applied for the department activity system. We noted that further changes may be required pending the creation of the department activity system.

The department activity system was derived from composite discussions and reflections on each node from the individual level. It presented a more holistic picture of education technology integration among engineering educators in the department:

1. For the department activity system, I went back to the data per CHAT node from the individual activity systems i.e., the extracted MS Word files.
2. This data was manually organised into tables with two columns for each CHAT node: one for the coded data, one for researcher notes (see Table 3). Thus, each CHAT node had a table with relevant data from all the educators.

Table 3: Example of Community Node Data

Data	Researcher Notes
I'm heavily involved with Eskom, interface with industry quite regularly.	Community: industry
And I think especially as I think of my role as a programme convenor in the Mechanical and Mechatronic programme, there's also scope for being like how is this implemented? How is that information getting from there onto this computer, because that's also some of the stuff that we do.	Community: programme convenor

Data	Researcher Notes
And as we're seeing more and more resources available online, it's like if I need to teach something, and I want a different way to explain it, I will go to MIT open courseware, and I will look at how someone else has taught it. And that will inform my teaching.	Community: content creators international
We have um guest lectures come in from different industries so they talk to the students about the workplace they went into so… Actually, the guy from the banking industry cause banks love engineers, so he can talk to the students. And guys from entrepreneurship stuff. One guy started breweries so you can expose students. Ya, one of my, one of my final year project students. Um someone from the process industry come and talk to us, you know stuff like that. And from project management industry, stuff like that. So, I tell the students those are not recorded for you to be able to, you know.	Community: industry

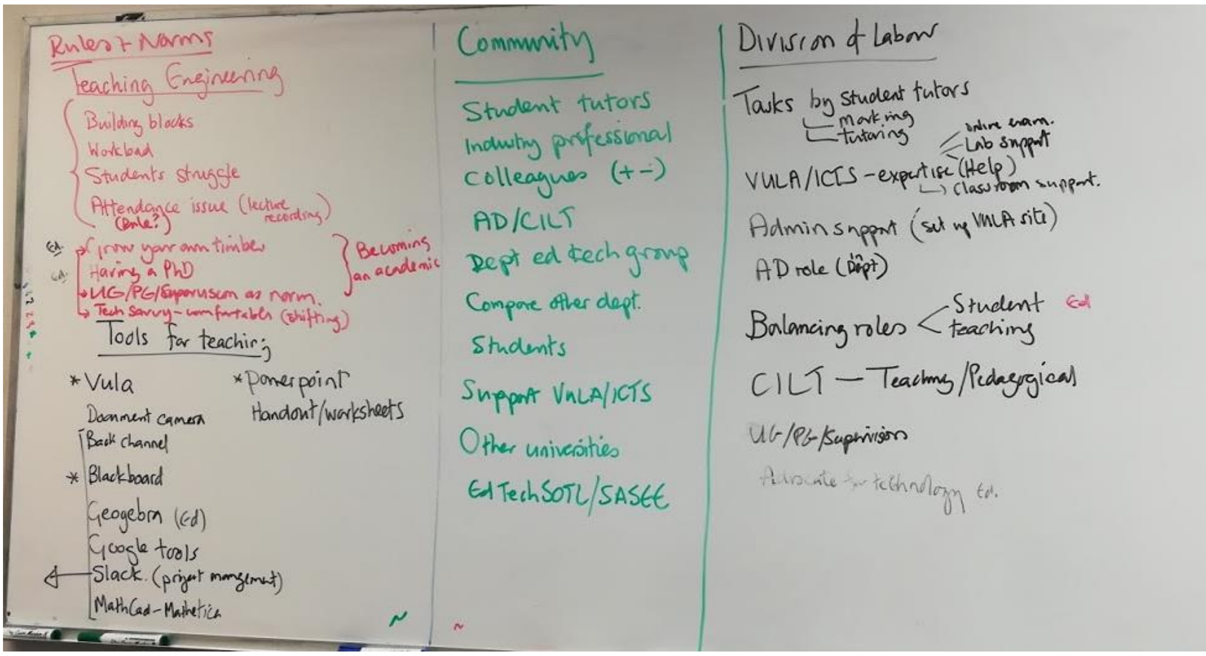
3. The tables were printed, cut up into strips and manually rearranged to ascertain commonalities in the data. This helped me to understand enabling and inhibiting forces for education technology integration. With reference to the example provided in Table 3, the following strips or rows of data would be grouped together as it demonstrated a commonality of external community role-players in the community node.

I'm heavily involved with Eskom, interface with industry quite regularly.	Community: industry

And as we're seeing more and more resources available online, it's like if I need to teach something, and I want a different way to explain it, I will go to MIT open courseware, and I will look at how someone else has taught it. And that will inform my teaching.	Community: content creators international

We have um guest lectures come in from different industries so they talk to the students about the workplace they went into so… Actually, the guy from the banking industry cause banks love engineers, so he can talk to the students. And guys from entrepreneurship stuff. One guy started breweries so you can expose students. Ya, one of my, one of my final year project students. Um someone from the process industry come and talk to us, you know stuff like that. And from project management industry, stuff like that. So, I tell the students those are not recorded for you to be able to, you know.	Community: industry

My interpretation of the department activity system was presented to my supervisors for member-checking purposes. Meetings took place in which diagrams were drawn to help give perspective to the data. An example of such a diagram is provided below.



During this process, I was challenged to be bolder in my interpretations. At times, it was necessary to return to raw data and reassess interpretations made. This meant that updates were required of individual and department activity systems. I had to take logistical care to ensure that changes were applied in all relevant areas; the use of Comments and colour coding in Google Documents was extremely helpful to this end. Ultimately, my experience resulted in a deeper understanding of the data that aided in the metamorphosis of the results and discussion chapters.

4.5. Quality in Qualitative Research

There is a need to account for and reflect on the quality of any research. In qualitative research, this is sometimes referred to as validity (e.g., Cohen et al., 2013; Maxwell, 2009). For this study, I will be using Tracy's (2010) eight criteria for quality qualitative research.

Worthy topic. Qualitative research topics are worthy when they are relevant, significant, timely, and/or interesting (Tracy, 2010:840). Education technology has been a relevant resource at UCT. It became particularly significant during the #FeesMustFall movement from 2015 to 2017, when universities across the country were being shut down. This sparked my interest to pursue the topic of education technology integration in educators when I commenced the research component of my Master's studies in 2018.

Rich rigour. This is concerned with requisite variety, where the tools used in research are at least as complex and rich as the matter under study (Tracy, 2010:841). While rich rigour is "necessary but not sufficient" for quality research, it does demonstrate face validity, that is, if a study appears to describe what it purports to examine (Tracy, 2010:841). One should consider the sampling and data collection process as well as the quality of data collected to ascertain rigour (Tracy, 2010:841). I collected data from one-third of the teaching staff in an engineering department. Considering my aim was to look at education technology integration among engineering educators, the sample, in this case, is relevant. As this was a qualitative study, I used the appropriate technique of semi-structured interviews (see 4.3.2). The data's quality will be shown in the next chapter, which presents the data as results.

Sincerity. This is marked by the researcher's self-reflexivity and transparency (Tracy, 2010:841). Self-reflexivity can be accounted for when researchers are cognizant of their biases and motives. They also need to consider their suitability with the research site (Tracy, 2010:842). I believe I was suited to enter the research site, as there was an established comfortability between myself and the participants. However, I was concerned with the assumptions or conclusions I would make during the interview process, due to my insider perspective. To best combat this, I ensured that I verified my interpretations of participants' responses during the interview. Transparency is the level of honesty exhibited in the research process (Tracy, 2010:842). In order to account for this, I documented my methodology and provided rationale for the research choices I made.

Credibility. This is concerned with trustworthiness and the integrity of research findings (Tracy, 2010:842). Researchers should demonstrate a thick description through tacit knowledge (Tracy, 2010:843). I have been at the university for eight years and a member of staff at EBE for three. Therefore, I believe I have accumulated the necessary tacit knowledge that will help me provide a thick description of my data in the following chapters.

Triangulation and crystallisation are also markers of credibility. The methods to achieve these are similar, but their views of the world differ. Both are concerned with the collation of various sources to provide richness (Tracy, 2010:843). However, triangulation is concerned with the convergence of similar conclusions, whereas crystallisation allows for multiple truths as it recognises complexity (Tracy, 2010). This means that triangulation does not suit interpretivist research (Tracy, 2010:843). Crystallisation is more suited to demonstrate credibility for my study.

Multivocality contributes to crystallisation as it is concerned with multiple voices in the analysis (Tracy, 2010:844). In this case, that meant interviewing multiple educators in the department. Familiarity with participants also allowed for comfortability and collaborative participation, thus contributing to multivocality (Tracy, 2010:844).

A final consideration for credibility was member reflections, which encouraged participant collaboration with the findings (Tracy, 2010:844). Member reflections in the traditional sense were not implemented in my study. This was because most participants only expressed interest in the final dissertation product or a published paper, not drafts of findings. Nevertheless, I supplied recordings of the interviews for participants to comment on. I did not receive any requests for changes.

Resonance. This is the researcher's ability to convey their research in a way that resonates with the reader (Tracy, 2010:844). To do so, the research should be well written and easy to comprehend (Tracy, 2010:845). One should aim for rich accounts throughout to assist with transferability of the results (Tracy, 2010:845). Resonance was an issue that I was cautious of due to my insider position, which may have blurred my assessment of whether my writing was clear to audiences outside of the study context. To combat this, I deliberated with my supervisors. As experienced qualitative researchers, they were able to better evaluate the resonance of my writing.

Significant contribution. I will achieve heuristic significance by exploring research limitations, thus noting future research suggestions as advised by Tracy (2010:846). Other relevant contributions such as practical and theoretical contributions will be laid out in subsequent chapters.

Ethical. These considerations were laid out in previous sections of this chapter.

Meaningful coherence. This is concerned with whether this dissertation reached its goal(s) via the appropriate means or methods and whether chapters are coherently connected (Tracy, 2010:848). Although I endeavoured to achieve this with the guidance of my supervisors, it would be overconfident of me to argue for meaningful coherence in my dissertation. Thus, I will leave the reader to conclude on the meaningful coherence of my dissertation.

With the intricacies and logistics of the study laid out above, I will now move on to results and discussion of the data.

Chapter 5: Individual Activity Systems

This study seeks to describe educators' experiences of education technology integration through the lens of activity theory. The object is, thus, the integration of educational technologies. The subjects are the participants in the study. Outcomes are derived from educators' instances of integration and their underlying purposes. Mediating tools include various artefacts that enable subjects to achieve the object. The bottom nodes of community, division of labour, and rules and norms are contextual nodes highlighting the conditions that enable or constrain educational technology integration.

Each educator's activity system diagram will be presented followed by a discussion into each node.

5.1. Chad's Activity System

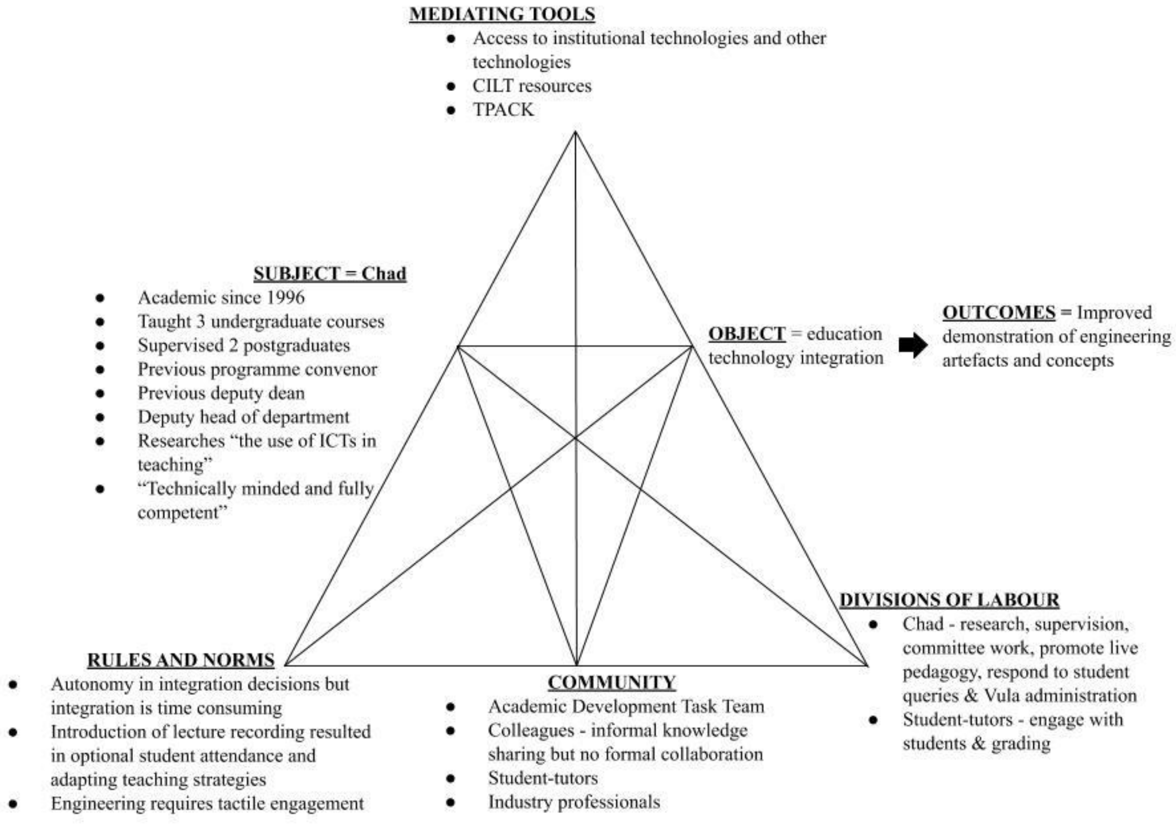


Figure 6: Chad's activity system

Since the beginning of his career as an educator in 1996, Chad has taught three separate undergraduate courses and supervised two postgraduate students. In the past, Chad was a deputy dean, and at the time of the study, he was both a course convenor and deputy head of department with a research interest in “the use of ICTs in teaching”. Chad described himself as “technically minded and fully [technically] competent”.

5.1.1. Outcomes

Chad’s instances of integration pointed to the affordances of technologies to improve the demonstration of engineering concepts. Using the document camera, he was able “to illustrate and demonstrate engineering artefacts [...] so that [students] can see how things work”. Instead of circulating artefacts in lectures, Chad could manipulate them under the document camera for the class to see. Chad also used videos to “demonstrate and articulate particular points”, which was more convenient than bringing “props” to class.

5.1.2. Mediating Tools

Chad’s access to and awareness of various technologies mediated his integration. As the majority of his instances of integration were institutionally-supported technologies, his access was most likely underpinned by the reliable technical and support infrastructure highlighted in Chapter 2, including:

- Using Vula’s Sign-Up function “for prac[tical]s and lab[oratorie]s”,
- Using a document camera “to illustrate and demonstrate engineering artefacts”, and
- Recording his lectures, initially using Camtasia, and subsequently, classroom-based lecture recording.

Educators with TPACK make integration choices informed by their knowledge of the subject content and the suitable pedagogical practices, both of which are enabled by technology. Chad’s accumulative experience as an educator likely contributed to his TPACK, motivating him to explore other technologies. Chad used Backchannel to allow students “to ask questions in real-time [...] but anonymously”, believing that it “would empower people to ask questions”. It was “the same people that will put their hands up, [...] and the others will continue asking questions through the Backchannel”.

Chad’s integration efforts were also mediated via “resources available through CILT” for enrichment purposes. These resources up skilled Chad’s ability to integrate education technologies and further contributed to his confidence and computer self-efficacy.

5.1.3. Community

When trying to gauge a sense of collaboration in the department towards education technology, Chad said that his colleagues "don't go around critiquing positively or negatively how we do things". However, there was an Academic Development Task Team in the department, where discussions on "how we engage with students in the most appropriate way" occurred.

There was an indication of informal knowledge-sharing, as Chad's colleagues took up Backchannel. Through observing Chad's experience of Backchannel, it boosted his colleagues' confidence towards the technology, leading to integration into their classrooms: "[O]thers have done it, have tried it, and some are still using it".

Chad also hired student-tutors to assist in his courses and invited professionals from industry as guest speakers to stimulate his lectures.

5.1.4. Division of Labour

In addition to his regular duties as an educator, including research, supervision, leadership and management roles, Chad took on the administration and set-up of his Vula sites, work which is often undertaken by a departmental administrator. Chad accounted for this by asserting, "It's about quality control. It's about taking ownership". Constructing the site included tasks such as uploading presentations and posting announcements on Vula. Chad "enjoy[ed] engaging with technical stuff" and "can't imagine not running the show [him]self".

As a lecturer, Chad responded to student queries. He chose to do this at "any time of the day or night" believing that if "you can assist a student when they have difficulty, they can then build on that going forward". But he did not help "a student if they can't demonstrate how they've tried to solve the problem".

Certain course duties, such as grading assignments, were outsourced to student-tutors who also "engage[d] with the students, helping them with the activities".

5.1.5. Rules and Norms

Chad's experience of rules and norms were associated with the cost of autonomy, lecture recording and attendance, and the need for "tactile engagement" in engineering education.

5.1.5.1. Autonomy

While there was autonomy in terms of education technology integration, Chad noted that this was time-consuming. He said, “There are things I’d like to do and things I don’t do because I don’t have the time”. But Chad chose to “make the time available and do it myself”. Chad’s computer self-efficacy and commitment to teaching and learning counterbalances the time-cost of integration.

5.1.5.2. Lecture Recording: Attendance

Chad experienced a shift of rules, from attendance being regarded as compulsory (although not enforced), to one in which attendance is accepted as voluntary. Although Chad supports the default adoption of lecture recording, he noted that this change brought into question the value of compulsory lecture attendance. “[U]p until a year and a half ago, it actually said in our general rules for students that attendance at lectures was compulsory”. When Chad highlighted this to the Senior Leadership Group, “they were horrified”. Attendance at lectures became voluntary as “something can only be compulsory if you are going to monitor it and be able to take action based on non-compliance”.

The introduction of lecture recording also required Chad to adapt teaching strategies to encourage class attendance. Chad thought, “[I]t’s up to us as [educators] to make sure we put on a show that’s worthy of them coming to class”. He compared recorded lectures and attendance to seeing “a movie on the big screen or going to see a theatrical stage production. [...] the stage production has just got so much more to it”.

5.1.5.3. Teaching Engineering: “Tactile Engagement”

Chad explained that learning engineering involves “theory supported by practice”. Thus, courses incorporate practical elements, such as on-campus “practical experiments and practical observations”. This highlighted the importance of “tactile engagement” for engineering. Without tactile engagement, one would be “missing something from an engineering education”. This requirement also prevents certain engineering specialisations from moving online completely: “[T]here’s too much practical stuff that’s needed, hands-on stuff”.

For example, Chad noted that the “things that aren’t self-studiable are the design elements. Because often you are working as part of a team”. He highlighted the importance of collaborative learning where students learn to “develop the human bond and engage in a way that actually develops their ability and work in teams". Students will "work as part of a team [...] in industry"; part of tactile engagement was to "mimic" this experience.

As UCT has been an almost exclusively face to face institution, educators did not "the skill to be able to create the necessary environment to enable quality online learning". Thus, Chad "was very grumpy when this whole idea of online" occurred during the disruptions. "[A]t best, there was blended, but it wasn't even blended because there was no face to face, it was just not satisfactory".

5.2. Ryan's Activity System

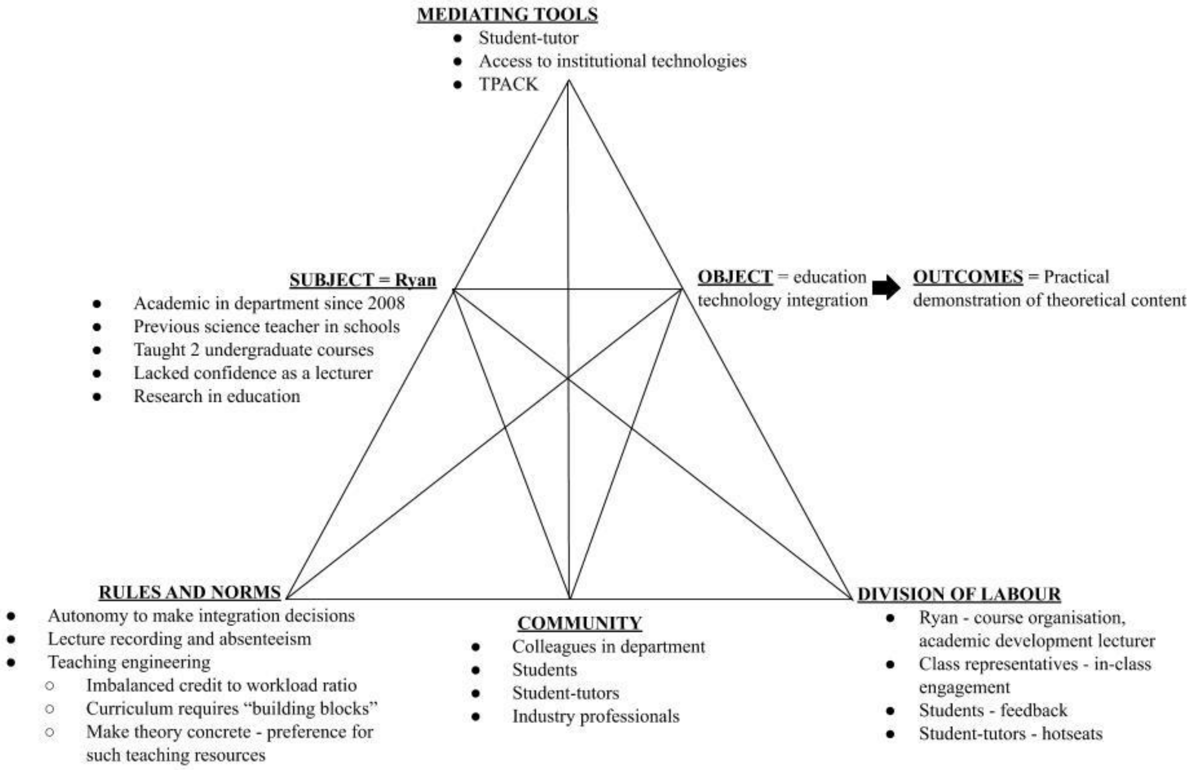


Figure 7: Ryan's activity system

Previously a school science teacher, Ryan joined the department in 2008, teaching two undergraduate courses and researching engineering education.

Ryan seemed to lack confidence in his ability as a lecturer. He noted that a colleague he co-taught with was "a very good lecturer" and noted that "the class attendance just drop[ped]" when he took over. Ryan stated that he was "not as good as [his colleague]" and believed that "everyone knows that".

5.2.1. Outcomes

Ryan's instances of integration showed education technology's ability to demonstrate theory in practice. Ryan used a miniature trebuchet and engineering content videos to provide entertaining practical examples in his classes.

5.2.2. Mediating Tools

Through the university's infrastructure, Ryan had access to institutional technologies. This access mediated his ability to integrate education technology, including:

- Using Vula's Gradebook, Online Resources and Sign-up functions, and
- Using Microsoft PowerPoint for teaching vector diagrams, as Ryan believed it to be effective. "You just click the button and the next arrow appears, the next one appears, you can use colour coding and whatever".

Drawing on his TPACK, Ryan integrated education technology to help "students to understand the thing conceptually", such as using visuals to assist with the assimilation of engineering content. When integrating, Ryan would "weigh up the benefits" of the set-up time versus the pedagogical reward of the technology. Thus, Ryan's TPACK mediated the following instances of education technologies:

- Ryan used a miniature trebuchet and engineering content videos to demonstrate theory in practice, and
- Ryan used a Wiley textbook and its online resources. The Wiley resources provided "all the problem diagrams as Microsoft PowerPoint slides" along with "all the solutions". Ryan thought this was "really useful" as it meant he did not need to create the slides from scratch.

A student-tutor also served as a mediator for Ryan by introducing Google Docs to Ryan as "before that, [Ryan] didn't use it".

5.2.3. Community

Ryan attempted to initiate seminars to promote knowledge-sharing, "but somehow it didn't really get off the ground". This may explain Ryan's lack of confidence in his pedagogical abilities, exacerbated by observations of his colleagues' pedagogical efforts. It was clear that Ryan was willing to learn from others. However, the poor uptake of his seminars combined with his colleagues' "really good" efforts may have intimidated Ryan, contributing to his lack of confidence.

Ryan's community included industry professionals who were guest speakers at his courses. Ryan invited a variety of professionals such as "a guy from the banking industry 'cause banks love engineers [...]. And guys from entrepreneurship stuff. One guy started breweries [...], someone from the process industry [...], and from the project management industry". This gave students an idea "about the workplace" and the various areas in which engineers may work.

Other role-players in Ryan's community included students, class representatives, and student-tutors. It was a student-tutor who introduced Ryan to Google Docs. Ryan also had an interesting interaction with a student on his course. The student shared a video on "the conservation of angular momentum of rigid bodies. It was basically why cats always land on their feet. Cool video of a guy dropping a cat in slow motion showing what the cat does and looking at it in terms of its physics". Ryan planned to "use that video going forward". He liked "when students give you stuff like that". Interestingly, while Ryan was unable to stimulate collaboration from his colleagues, he was able to learn from his students.

5.2.4. Division of Labour

Ryan was an academic development lecturer in the department, where he provided input on others' teaching. He enjoyed this experience as "it's quite an eye-opener. You actually learn quite a lot from other people, the way other people teach". There were seven academic development lecturers at the faculty in 2018 who served on an academic administration and management committee handling undergraduate matters (UCT, 2018:5). As part of this role, Ryan was also involved in the "mentoring system, tutoring system, and lead the Academic Development Task Team in the department and look[ed] at the statistics and the throughput, and deal[t] with admissions". Ryan was also responsible for the organisation of his courses. This included locating, sequencing, and presenting the course material, activities, and assessment.

Ryan delegated tasks to student-tutors on his courses. They managed hotseats, i.e., time slots where students asked content questions. These were "quite well attended". Students in class provided feedback which Ryan used to assess his integration efforts. For example, with regards to his Vula duties, Ryan noted that "the students are really happy with how the course is organised".

5.2.5. Rules and Norms

Ryan's experience of rules and norms included autonomy, absenteeism in relation to lecture recording, and various matters related to teaching engineering.

5.2.5.1. Autonomy

Ryan's integration of education technology was enabled by autonomy in the department. "[E]veryone does what they think is best", and there was "a lot of autonomy in the class". Despite the lack of formalised rules in the department, there were still norms in place regarding preferred methods of teaching. Ryan explained that if he "decided to do chalk and talk [...] people would maybe raise some eyebrows" as there was "a general sort of push to go more towards using technology and blended learning".

5.2.5.2. Lecture Recording: Absenteeism

There was a shift towards institutional education technology integration with default lecture recording in enabled spaces. This shift was reinforced by students' expectation for "better access to resources". Ryan thought that if students "can get value out of the recording, then why attend?" Ryan was inclined to believe that absenteeism was because recorded lectures enabled convenient learning spaces beyond the classroom. Ryan explained that this helped students to prioritise their responsibilities, as "traditionally, that first-semester course, the attendance drops off quite heavily after the first term". Ryan's use of the term "traditionally" suggests this attendance pattern as a norm. Both instances promoted learning spaces beyond the classroom, but it was easier for Ryan to normalise productive absenteeism than convenient absenteeism.

5.2.5.3. Teaching Engineering

A UCT rule dictates that each course be rated in terms of credits, whereby "one credit is supposed to be equivalent to ten hours of work". But Ryan's courses were "conceptually tough" so students "tend[ed] to spend longer on [them]". Ryan indicated efforts to conform to this rule by "changing [the course]. We're taking out some of the really hard stuff which is maybe not that necessary".

The curriculum model was designed using "building blocks", a teaching norm in this department. Ryan's courses were "very difficult" to follow without the necessary "building blocks". One particular building block was Ryan's approach to vector equations. While other approaches exist, Ryan believed his method helped students to "get a sense" of the problem.

Like Chad, who valued practical elements to make theory concrete, Ryan focused students' time on practising multiple "worked examples" to apply the theory. He noted that this was standard as "tut[orial]s [were] the main area where you actually do your working".

The visualisation of concepts has become a norm for teaching the complexities of engineering. Ryan used a miniature trebuchet, "a launching machine used in the middle ages", to demonstrate energy transfer "from potential to kinetic". Ryan followed this up with "a video of a guy launching a burning piano in a massive trebuchet". Ryan also used a video of "a really fast boat going around really tight corners" to show "normal and tangential forces". Another video had "high-speed cameras to show how the golf club distort[ed] the ball" to demonstrate "the physics behind it". Ryan so valued videos as a teaching resource that he expressed the desire to "develop videos, animations" in-house.

5.3. Nick's Activity System

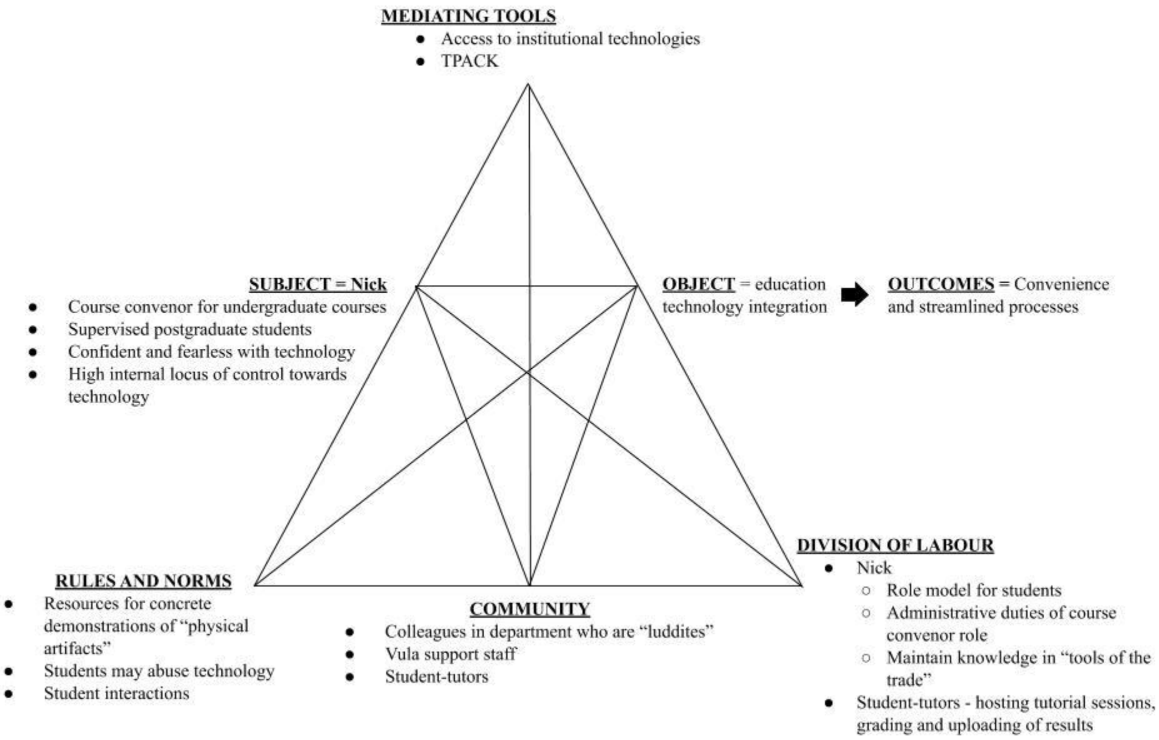


Figure 8: Nick's activity system

Nick acted as a course convenor for two undergraduate courses and supervised postgraduate students. He was on sabbatical at the time of the interview.

Nick has a very confident and independent attitude towards working with technology. Nick attributes his "degree of fearlessness around computers" to being exposed to computers at a young age, as well as being taught that "it's practically impossible [...] to break computer hardware with software commands". His confidence was further bolstered by engaging in "fairly advanced computing" during his PhD. As "an independent learner", Nick preferred integrating technologies "in [his] own time, at [his] own pace". He expressed confidently that, once he understood the technology, it would work "reliably, every single time".

5.3.1. Outcomes

Nick's integration efforts were aimed at convenient and streamlined outcomes. These outcomes were of such value to Nick that he was willing to "take some time" to learn a new technology if it were to "save you time downstream".

In particular, Nick regarded Vula as "a great labour saving tool and it's a great accounting tool". Nick used Vula's Assignments function to monitor students' adherence to deadlines, ensuring a fair and hassle-free submission process. Vula's Q&A function reduced repetitive queries and helped Nick to stay connected with his students while travelling for a conference in 2014.

Nick also used the document camera to create videos that contributed to his database of teaching materials, thus streamlining his future practices.

5.3.2. Mediating Tools

Via pre-existing institutional infrastructure, Nick had access to institutional education technologies. This mediated his ability to integrate technologies such as Vula and the document camera.

Nick's "engineering background" contributed to his TPACK. This mediated his exploration into other education technologies, such as Google Spreadsheets, which he used to track student-tutors' grading progress. Nick's belief that "there's very often a good tool to use for a job" showed his preference for technologies that contribute to pedagogy (TPK) and content (TCK).

5.3.3. Community

Colleagues approached Nick for assistance on "using Google tools", asking him for "a seminar on it". Thus, colleagues viewed Nick as a knowledgeable user of education technology. Nick decided that it was the department's responsibility to coordinate such seminars. He explained that the department "just [hasn't] gotten around to actually putting that together".

Nick regarded his colleagues as "luddites" who "really are technophobes of note" with a "very very different relationship with computers". As a confident user, Nick was both "amused and horrified". He thought it "very strange because they [were] engineers". As engineers, Nick expected his colleagues to be technologically competent, particularly as there was an expectation for their students" to be more technologically literate than the average person". Thus, Nick found it ironic when his colleagues “[couldn’t] work this very basic part of modern computing”. Nick has tried to encourage his colleagues to “go figure out” Vula functions, noting that “it’ll change [their] life”. They responded with confusion, wondering, “[W]hy would I want to do this kind of thing?” It was fine if these colleagues were the “old, grey-haired professors”, as “they didn’t grow up in that space”, but Nick noted that these were “people who are closer to [his] age”. So, Nick believed that this was “their problem, not [his]”.

Nick’s experience of community was dominated by his frustrations with his colleagues. I believe this can be attributed to his preference for control. As an independent learner, Nick could not understand why his colleagues, engineers who supposedly had a reputation of technical fluency, could not figure out technology as he did. As Nick was unable to persuade his colleagues to attempt education technology, he was no longer in control. Thus, he avoided the opportunity to up skill his colleagues, instead deferring to the department to offer Google application seminars.

Nick also interacted with student-tutors on his course and university support services. He interacted with Vula support staff during his integration efforts, as he had a personal contact on the team. This allowed Nick to meet “people directly” or “could just email them”.

5.3.4. Division of Labour

As a course convenor, Nick had administrative responsibilities, such as overseeing the upload of results from his student-tutors. Student-tutors also hosted tutorial sessions and graded assignments.

As an engineer, Nick felt responsible to “be conversant” in engineering technology, as it “gets updated every year”. He said, “These are the tools of my trade and I need to be proficient with the tools of my trade”.

As a lecturer, Nick saw himself as a professional role model for his students thus he emulated his own student experiences. Nick’s “lecturers taught content knowledge. But they were also models of how to be in that profession”.

5.3.5. Rules and Norms

Nick's experience of rules and norms included teaching engineering, student interaction and students' use of technology. Nick worried that students may abuse technology. When "using a particular textbook", Nick observed that students would download the solution manual to "try and memorise the solutions for the questions that they think are coming up". Nick disapproved of such behaviour as it did not show students understood the material.

5.3.5.1. Teaching Engineering: Resources for Demonstration

Teaching engineering requires resources that enable concrete demonstrations of "physical artefacts". Nick's courses involved "a lot of machine components", such as gears and pulleys. These components were small and difficult to see in a big lecture theatre, where "people in the back row get nothing". Nick applied for and was granted funding for a document camera, which helped to display artefacts.

5.3.5.2. Student Interaction

A norm for Nick's management of student interactions was to "police the grey end of the boundary". This meant exercising discretion on his availability with various contingencies. Generally, Nick required students to "email for an appointment", as he "[taught] on three courses [and had] multiple postgraduate students". Final year undergraduate students had discretionary access to Nick's mobile number, as they were "mature enough to manage the grey". Similar to Chad, Nick determined if queries were worthy of a response. Nick was also reluctant to address queries over the weekend, particularly if it was "a question that was asked by five different people in a tutorial during the week".

During the disruptions, Nick expanded the grey area and responded to email queries as soon as possible, even on weekends. He understood that students were "constrained" in terms of "internet and email access". Policing the grey was imperative to Nick's work-life balance, as "people have families; people have lives outside of this place".

5.4. Ted's Activity System

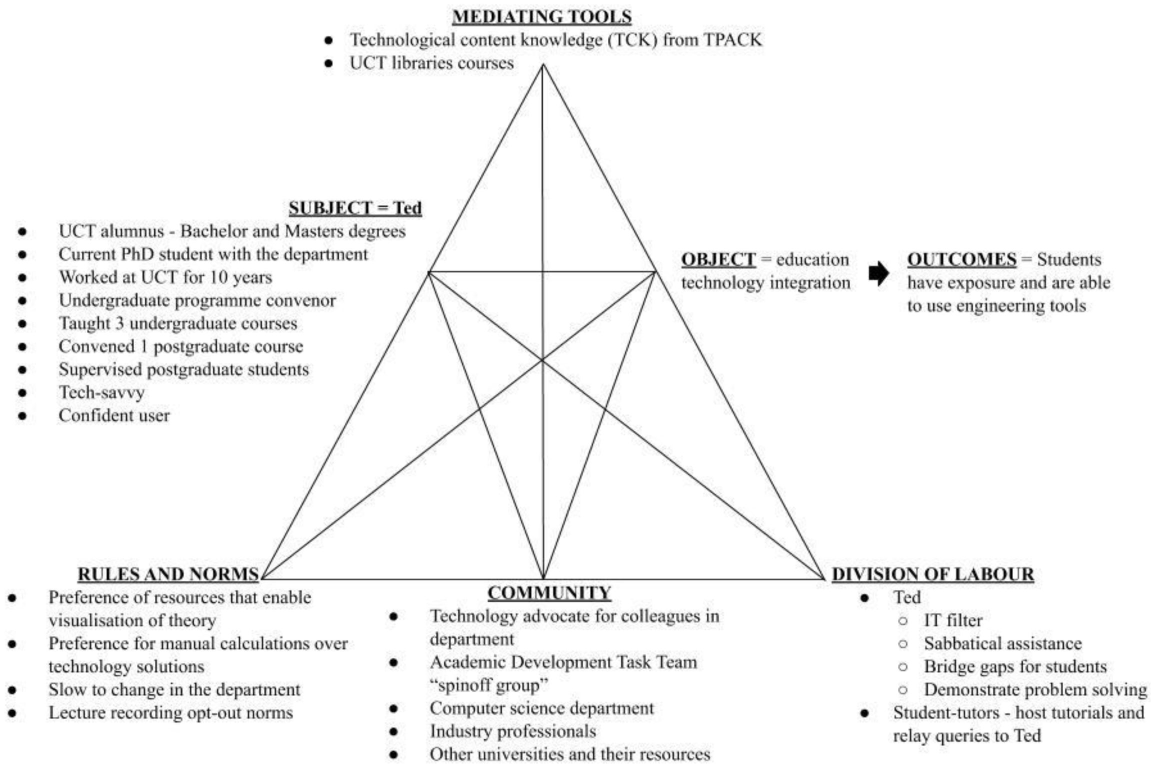


Figure 9: Ted's activity system

Ted has been employed at UCT for ten years. His journey embodied the department's philosophy to "grow your own timber". After his undergraduate studies at UCT, Ted became an assistant lecturer while completing his Master's. Upon graduation, he was appointed as a lecturer and enrolled for his PhD to progress in academia.

Ted was an undergraduate programme convenor, taught three undergraduate courses at various levels, convened a Masters course, and supervised postgraduate students.

Ted wanted to be "very tech-savvy", so he made "a point to learn" where possible. It was a "very empowering" experience which instilled confidence in his technical capabilities. Nowadays, Ted is one of "the most computationally capable [people] in [the] department".

5.4.1. Outcomes

Ted wanted students to have more exposure to engineering technologies used in professional practice, such as Slack, GeoGebra, Mathcad, and Mathematica. Currently, they are used by final year students. Second year students also have access to them. In future, Ted hopes that all students can learn to use these engineering technologies.

5.4.2. Mediating Tools

Ted's instances of integration were dominated by engineering technologies, including:

- Using GeoGebra, an interactive pedagogical mathematics software, to "draw a full-featured vector diagram in about ten minutes",
- Using Mathcad and Mathematica "to write technical reports with technical calculations". This was helpful when grading. "[I]f a student makes a mistake halfway through, they just change the value halfway through, and it just calculates everything else for them", and
- Using Slack, a channel-based communication platform, which was "very common in the IT world, less so in the engineering world". He used it to communicate and share resources with the students he supervised.

Presumably, Ted perceived the mastery of engineering technologies as the achievement of tech-savviness. Therefore, Ted's knowledge of engineering technologies (TCK from TPACK) mediated his ability to integrate education technologies.

As someone who makes "a point to learn", Ted attended a "Using Search Engines course" offered by UCT libraries. This contributed to his problem-solving skills, thus mediating his integration decisions.

5.4.3. Community

Ted seemed to have many ties in the department and other communities. He identified himself as an advocate for technology in his department. He "ensure[d] that all courses [were] using technology in ways that [were] meaningful, that will bolster teaching levels, but also for learning". Ted provided suggestions to colleagues on the appropriate technology to integrate into their courses.

Ted was a member of the departmental Academic Development Task Team "spinoff group", where they brainstormed tools to teach vector diagrams. While the desired solution was under development, Ted taught his colleagues GeoGebra for their classrooms. Ted was highly involved in his department, and others in the community appreciated Ted's involvement.

Ted was acquainted with other UCT communities. He admired the Computer Science Department's auto-marking capabilities for the convenience of grading students' computer programming submissions. The Computer Science Department also offered courses to engineering students in Ted's department.
In terms of external communities, Ted wanted to enrich those in industry by repackaging courses in the department. He envisioned courses that would be offered online in a "continuing professional development style". Ted also explored resources from universities "who specialise in teaching certain

things and who do it extremely well”. Ted used these resources to inform his teaching, and vice versa, shared his teaching materials with others.

Ted’s layered community node seemed different from the previous educators’. Nick gave up on his colleagues. Ryan’s attempts at collaboration failed. Chad inadvertently led his colleagues towards Backchannel. But Ted actively and persistently promoted the use of technology in his community, as well as sought out examples of innovation in other areas at the university.

5.4.4. Division of Labour

As a technology advocate, Ted acted as the “IT filter department”, informing education technology integration decisions. As “a jack of all trades” who was “quite adaptable”, he lectured courses for colleagues on sabbatical.

Ted employed student-tutors to help with the workload on his courses. Student-tutors assisted students during tutorials with debugging and were students’ first point of call. Student-tutors directed struggling students to Ted to “bridge [the] gap”.

As a lecturer, Ted acted as “a source of information”. He showed students how to solve problems by performing an online search or a calculation in Microsoft Excel. Students were often amazed at his resourcefulness.

5.4.5. Rules and Norms

Ted’s experience of rules and norms included ideas associated with teaching engineering, the department’s ability to change, and lecture recording.

5.4.5.1. Teaching Engineering

As engineering can be theory-heavy, which students did not enjoy, resources that enabled visualisation of theory were preferred. Ted recognised the importance of practicals via live demonstrations and videos. For example, “designing a shaft” could be demonstrated on Microsoft Excel. To help students visualise theory, Ted ensured that specialised software was available on campus computers for the last five or six years.

The department normally expects students to perform manual calculations. Ted did not fully support this practice: “[I]n terms of quickly checking something, or getting very accurate answers out, having a technological tool is really useful”. This suggests a curriculum preference for manual calculations over technology solutions in the department.

5.4.5.2. Slow to Change

In Ted's view, his colleagues were slow to change, and many viewed change as a painful process. When the department switched from MATLAB to Python for curriculum purposes, Ted observed that his colleagues experienced “headaches” and struggled to adapt. Ted believed that educators must stay ahead of the game, to “develop the thing that is going to put [them] out of business” and “take on the new role in time before someone else does”. Ted believed that educators were coming to this realisation slowly, supporting the current lethargic response to change in the department.

Ted was an exception in the department. He welcomed and implemented change. Ted piloted potential changes on non-final years who were “slightly less high stakes”, as he did not want to risk jeopardising final year students’ completion time by doing things “on the fly”. Ted’s purposeful approach to change was enabled by his involvement on various undergraduate-level courses, where he could run pilots.

5.4.5.3. Lecture Recording: Opt-out Norms

Traditionally, UCT’s face-to-face lectures provided a significant opportunity for the transfer of knowledge. Thus, educators tend to place considerable value on its attendance. Compared to his colleagues, Ted was less concerned with attendance. Ted thought it was “very hard to know” the impact lecture recording had on attendance, due to conflicting information between implementers and users: “The lecture recording team loves to tell us that there's no noticeable difference in lecture attendance between recording and not recording”. However, Ted has noticed a decline in attendance. This resulted in an opt-out norm among educators in the department when student attendance dropped below “two-thirds”. Although, Ted considered 30% attendance normal.

5.5. Keith's Activity System

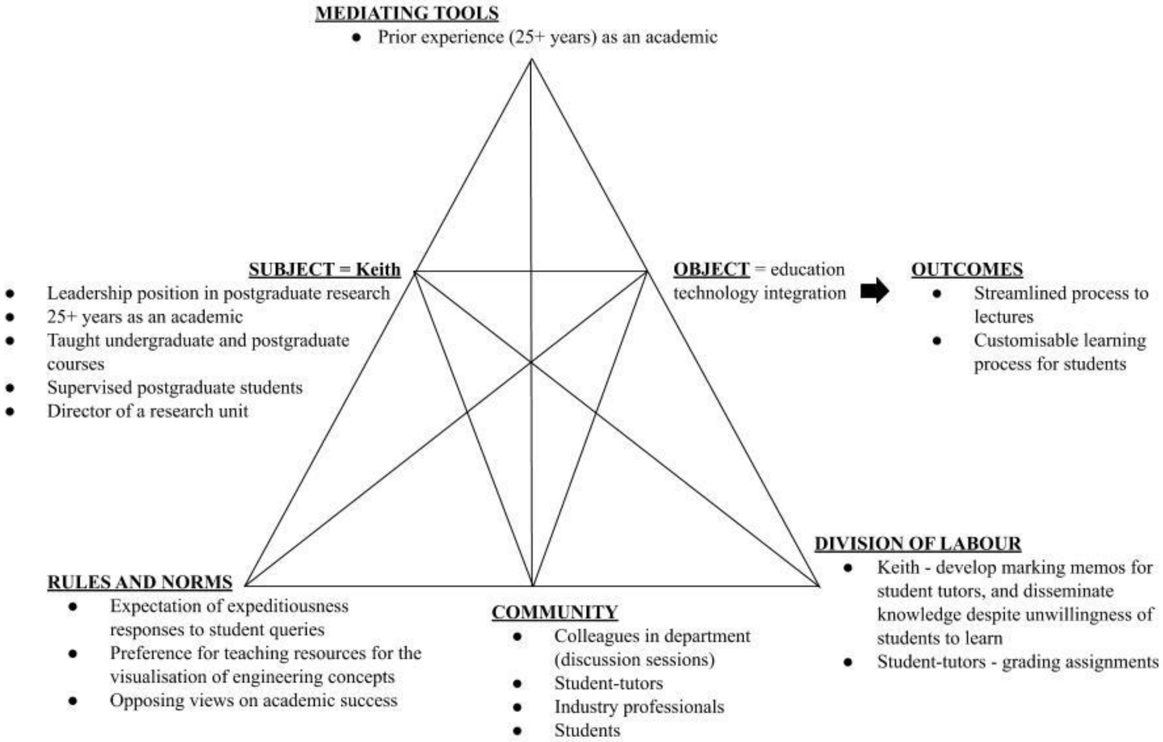


Figure 10: Keith's activity system

Keith joined the department four years ago and has been an educator for over 25 years. He supervised postgraduate students and taught both undergraduate and postgraduate courses. He was also director of a research unit and held a leadership position in the department's postgraduate research.

5.5.1. Outcomes

Keith's integration efforts were aimed at streamlining his lectures. For example, he used YouTube videos to explain minor details so that he did not have to.

Believing students should be agents in their academic journeys, Keith provided an abundance of resources and did "not hold anything back" so that students may tailor the materials to their learning. Thus, another outcome of Keith's integration was to provide a customisable learning process.

5.5.2. Mediating Tools

As the most experienced educator in the group, Keith's instances of integration were likely mediated by his prior experience as a lecturer, where knowledge gained over time contributed to his outcomes:

- Keith ensured students had access to his lecture slides via Vula prior to the lecture so that they could listen instead of writing "all the time". He believed this "add[ed] value".
- Keith used YouTube videos in lectures to avoid "explain[ing] every little thing".
- Keith arranged industry mentors for his students, but because these professionals may not have had time for face-to-face meetings, Keith used Google Meet to facilitate these discussions.

5.5.3. Community

Keith mentioned monthly departmental discussions, in which colleagues shared pedagogical ideas. Unfortunately, Keith did not have time to take part, which he admitted was "very bad", as he would not "have any other spare seconds" if he attended. This was because the department was "basically operating on a skeleton staff". Instead, Keith tried to have such discussions informally, e.g., during tea breaks. It seemed that Keith would have liked to interact with his colleagues more, but he was constrained by his workload and an understaffed department.

External to the department, Keith interacted with industry, from which he organised mentors for students.

5.5.4. Division of Labour

Student-tutors graded assignments, thus alleviating some of Keith's workload. He preferred to do the "other stuff" himself, as his subject area required time to "really understand the fundamentals".

As a lecturer, Keith struggled to disseminate knowledge, as "it [felt] like, [students] don't want to learn". Keith was "a little bit disgruntled" about this, as it contradicted his belief in student agency, where they "should be motivated to do their own thing".

5.5.5. Rules and Norms

Keith experienced rules and norms in relation to student interaction, teaching engineering, and views on academic success between educators and students.

5.5.5.1. Student Interaction

Communications technologies enabled, and therefore normalised, expeditious responses to student queries. Initially, Keith noted the time-consuming nature of this expectation. Thus, he encouraged the use of Vula's Q&A function, responding to queries for all to see. Likewise, when away at conferences, Keith encouraged his postgraduate students to contact him so that they did not “sit for a week and brood on something”. As Keith’s behaviour altered to accommodate new norms, he began to perceive communication technologies as “very effective” and “much more efficient”, noting that “it really benefit[ed] the students”.

5.5.5.2. Teaching Engineering: Resources for Visualisation

Similar to Ryan and Chad, “practical experience [was] actually important” for Keith. He preferred resources that enabled the visualisation of engineering concepts, such as videos’ ability to visualise “complex systems and how [they] all fit together”. It was “very, very effective” compared to “hand gestures”.

5.5.5.3. Opposed Views on Academic Success

Keith alluded to educators’ and students’ opposing views on the requirements for academic success. Students “underestimate what it takes to be successful”, mistaking acceptance to the university as guaranteed graduation: “[T]hey allowed me to enrol, that means I have the ability, which means I have to pass”. This was “not necessarily true”, as passing required “two things: sufficient intelligence, [and] a lot of endurance”.

These opposing views lead to difficult student interactions for Keith. He received an email wherein a failed student thought Keith “could have found some more [marks]” if he “looked a little bit harder”. Although shocked, Keith understood this was not “malicious, it [was] being ignorant”, as engineering was “not easy”. Despite being “quite a good student”, Keith “didn’t cruise through [engineering]; [he] had to work damn hard”.

Keith believed that, although harsh, it was better that students failed sooner rather than later. He did not want to push students through who were “going to fail anyway”. But it was “not politically correct for students to fail”, which was frustrating for educators. To minimise failures, Keith provided students with various resources to promote agency in their learning.

5.6. Dane's Activity System

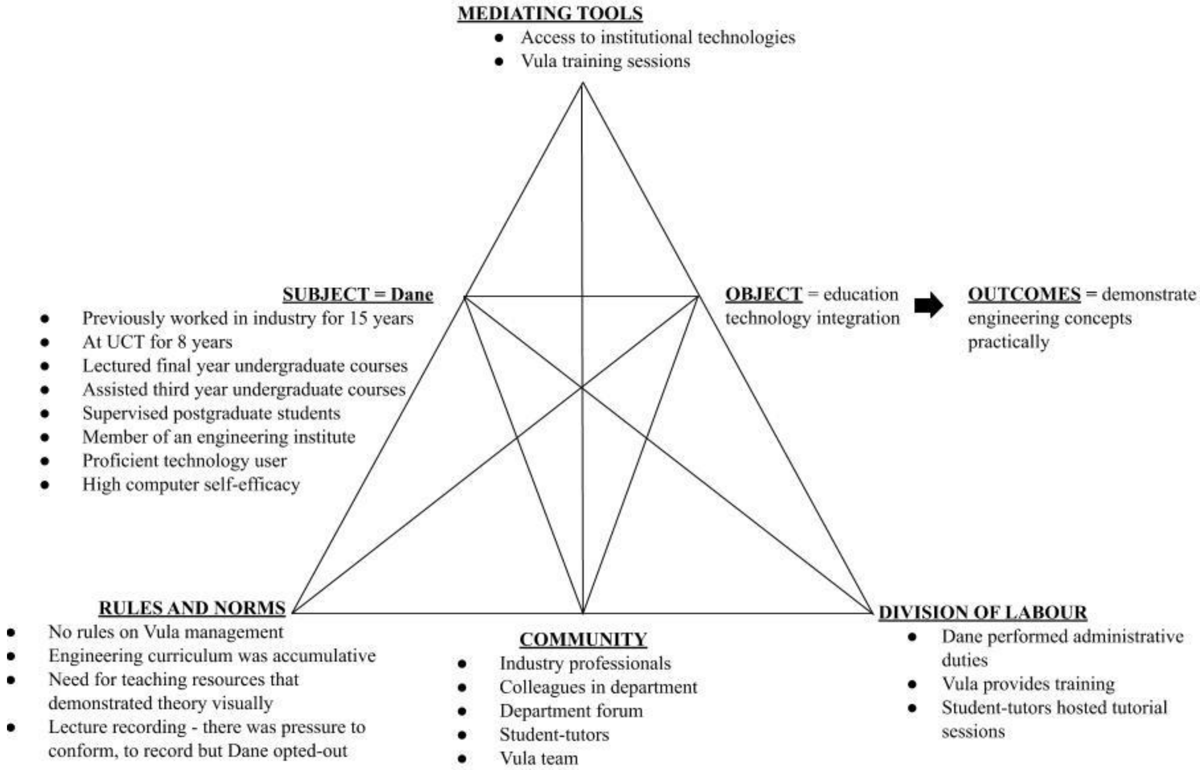


Figure 11: Dane's activity system

Dane worked in industry for 15 years before joining UCT eight years ago. He lectured final year courses, assisted on third-year courses, supervised postgraduate students, and was a member of an engineering institute which interfaced with industry professionals. He was a proficient technology user, as he "[understood] computers and how systems work[ed]". He displayed high computer self-efficacy, as he taught himself "most of the stuff".

5.6.1. Outcomes

In addition to his extensive use of Vula functions to manage and streamline classroom activities, Dane appropriated tools from other contexts to achieve an educational purpose. For example, he developed a 3D model of water "to demonstrate things and explain" how to derive a 3D environment from a 2D picture.

5.6.2. Mediating Tools

Facilitated by institutional infrastructure, Dane's access to institutional technologies mediated his instances of integration. This was particularly apparent as, with the exception of the 3D model, the majority of his integration instances utilised institutional technologies:

- Dane used Vula extensively, including its Assignments, Gradebook, Groups, Sign-Up, and Quizzes functions. He was particularly proud of his proficiency with Gradebook, which allowed students to monitor their achievements, as not many colleagues had used it. Although it took some time to perfect, the Groups and Sign-Up functions allowed Dane to assign students easily to his student-tutors.
- Dane used Microsoft PowerPoint for his lecture slides, but these were not accessible to students electronically, as the examples used were copyrighted. Instead, a copyrighted physical booklet was issued, as students seldom revisited the material after course completion.

Dane also attended Vula training sessions to up skill his integration abilities.

5.6.3. Community

Dane had an unfavourable view of the department's efforts to monitor education technology use. He observed a lack of "drive or standardisation or consistency", especially as it pertained to Vula use. Dane noted a forum where staff presented ideas, but it was not a "nice forum", as there was no concerted effort to ensure proliferation of the presented technology. Educators continued to do what "they [felt] they want[ed] to do".

Dane felt that the autonomy educators had may not be beneficial for effective technology use. However, it could be argued that autonomy contributed to his Vula proficiency, as Dane used Gradebook, which was not a popular function. If there had been standardisation in the department, Dane may not have discovered the functions he came to use.

In terms of other community experiences, Dane employed student-tutors to assist with his courses. He also utilised university support structures, such as training sessions offered by the Vula team.

Beyond UCT, Dane had strong ties with the professional community. In Dane's case, many of his students came from industry. Dane also convinced ex-colleagues from industry to mentor his students.

5.6.4. Division of Labour

Like Chad, Dane managed various administrative aspects of his courses, such as coordinating Vula Sign-Up sessions. Traditionally, Vula administrative tasks are delegated to departmental administrators, but Dane believed he was a “more powerful user on Vula” than the administrators. His “very hands-on” approach was due to the dynamic nature of his courses which required him to “continuously grow the Vula site as the course progress[ed]”. Course dynamism was particularly pertinent during the #FeesMustFall disruptions; depending on curriculum progress, Dane prepared a “plan B” to conclude his courses.

Another division of labour noted included the Vula team, who offered training support, and his student-tutors, who hosted tutorial sessions on his courses.

5.6.5. Rules and Norms

Dane experienced rules and norms regarding use of Vula, teaching engineering, and lecture recording.

5.6.5.1. Vula Autonomy

Generally, there were no requirements for the management of Vula course sites. The only time Dane received instructions was when he provided materials on a predefined Vula site for accreditation purposes.

5.6.5.2. Teaching Engineering

The engineering curriculum was accumulative, as it “[fed] into each other”. Thus, “if anything trips up, it really crashes”. Similar to Keith, Dane valued teaching resources that demonstrated theory visually. Hence, Dane created a 3D model of water for practical demonstration. Dane said, “You can talk the theory, but it doesn’t get home with the students, they need to experience it”.

5.6.5.3. Lecture Recording: Pressure to Conform

Empowered by university mandate, lecture recording became the modus operandi. Dane expressed pressure to conform: “The pressures from the university as a whole drives in different directions”, and “not many people have got the energy to protest against what is expected”. Despite the pressures to conform, Dane opted-out, stating that he did "not feel comfortable to record [himself]" and students should "focus in class".

He was also concerned with freedom of expression. Dane "want[ed] to be able to communicate freely and try to help most students". But if he "[made] a joke that didn't necessarily fit that well" with a specific student, he feared that student would "use it against [him], because [Dane has] now discriminated against [the student] for some or other reason". Furthermore, lecture recording jeopardised the confidentiality of the intellectual property in Dane's lecture materials, as they would then be available electronically.

5.7. Mia's Activity System

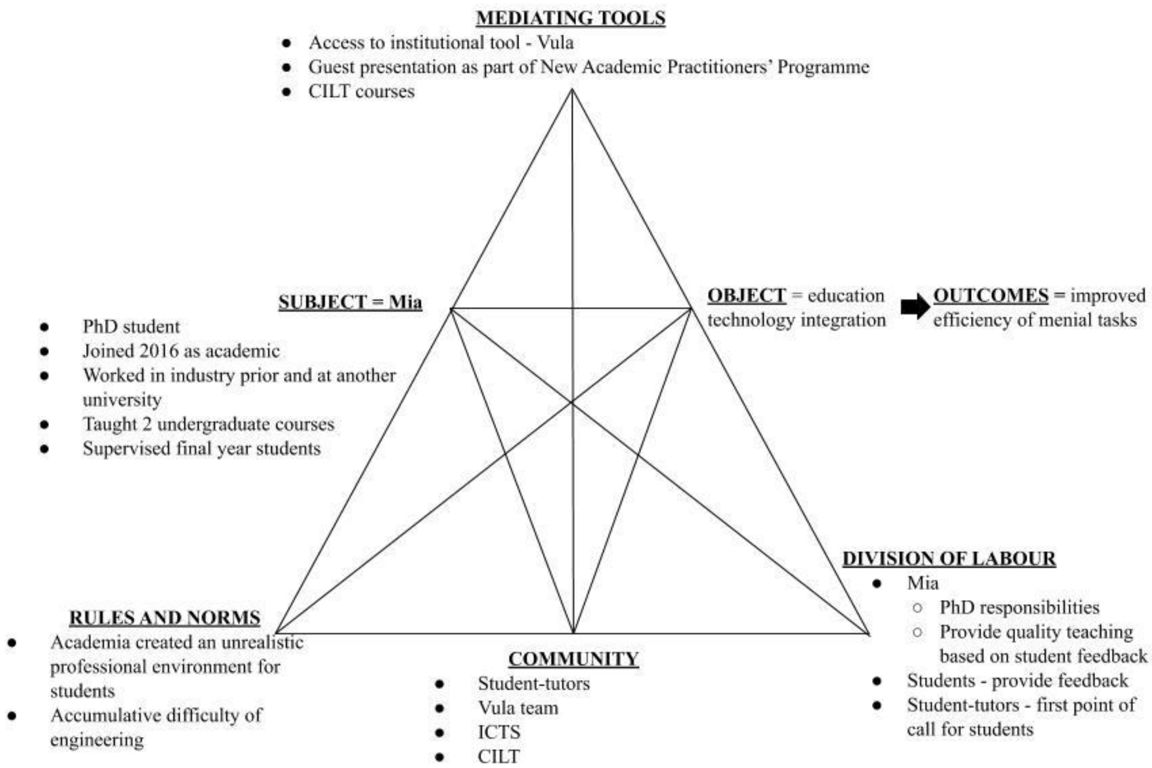


Figure 12: Mia's activity system

Mia was a PhD student who joined the department in 2016, lecturing two undergraduate courses and supervising multiple final year students. Previously, she worked in industry and at another university.

5.7.1. Outcomes

Mia's integration efforts revealed an outcome of improved efficiency for the menial tasks she performed. For example, scheduled uploads replaced the need for her to remember to upload "the damn things", i.e., lecture slides.

5.7.2. Mediating Tools

Mia participated in the New Academic Practitioners' Programme as part of her orientation as an educator at UCT. It included a guest presentation on education technologies, which may have mediated her integration. Mia also sought out courses on "interactive-type" lectures from CILT to further mediate her integration efforts.

Mia's instances of integration were mediated by her access to the institutional tool, Vula, which was enabled by institutional infrastructure. She used Vula's Q&A function to respond to student queries and scheduled uploads via the Lessons function which she renamed to Lecture Notes. Vula became a central tool for Mia's course management.

5.7.3. Community

Similar to other educators, Mia employed student-tutors for assistance. Previously, Mia interacted with CILT for their resources on pedagogy. Mia also interacted with other technical support services at UCT.

When preparing a practical exam, Mia received feedback from the Vula team. Thus, she assumed the team was monitoring the exam. She was horrified when she realised they were not, and students had unrestricted internet access during the exam, meaning students may "100% be cheating". Mia contacted ICTS, who in turn contacted the Vula team, with no response. By the time Mia's exam commenced, ICTS closed and could no longer assist her. The situation worsened when multiple computers crashed during the examination.

Mia recalled the ordeal as "a nightmare" and was plagued by "nightmares the whole weekend". She thought the support services were "incredibly unprofessional, incredibly stressful on the students". Mia posited that the poor support was due to "big companies like Amazon" who "absorbed most of ICTS" with more competitive packages. This made matters "very tricky".

Mia's unfortunate experience may lead to future avoidance of UCT's support services, especially as she expressed that she would seek out alternative methods in the future.

5.7.4. Division of Labour

Student-tutors assisted Mia by acting as the first responders to students. As a PhD candidate, Mia balanced both educator and student responsibilities. But teaching occupied most of her time as there was immediate feedback if she gave “a rubbish lecture”.

Although students provided feedback to educators, Mia often received “strange feedback” where students requested class tests “to force them to engage with the work”. Mia also noted that the amount of feedback was “pretty dismal” and “not terribly useful” often coming from “two ends of the spectrum” - either those who enjoyed the course or the few who hated it. Mia preferred hearing from “the middle ground or the almost like just failing people” to improve her teaching practices.

5.7.5. Rules and Norms: Teaching Engineering

Similar to other educators, Mia pointed out the accumulative difficulty of engineering, noting “the workload runs up fast”. To help students stay abreast, she hosted mini-assessments at the end of practicals. She found that those who were unable to finish a practical struggled to complete future practicals: “[I]t snowballs”.

Mia noticed students who were absent from lectures “fade[d]” from the course and “complain[ed] because they ha[d] no idea what [was] going on”. When lecture attendance “just disappear[ed]”, students fell behind. The matter was worsened if students did not understand the material and did not ask questions to clarify.

Academia created an unrealistic professional environment for students. For example, summative assessments created “a very stressful environment” which did not produce “an adequate reflection” of students’ capabilities, as they had to perform “without the resources [they] normally [had]”. As a result, Mia tried to emulate a professional environment, encouraging students to build a portfolio for future job interviews. She hoped students would be “more invested” and “put more pride and effort” into their work.

5.8. Craig's Activity System

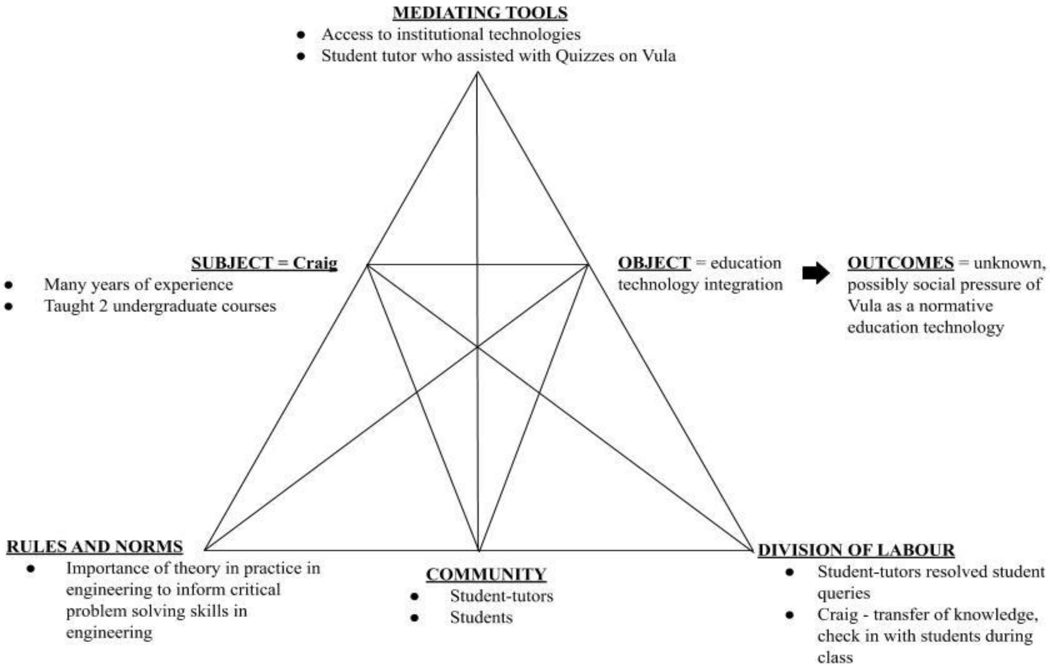


Figure 13: Craig's activity system

Craig started his career in the mid-90s. He taught two undergraduate courses.

5.8.1. Mediating Tools and Outcomes

Mediated by access to institutional technologies through UCT's infrastructure, Craig used Vula's Quizzes function. He initially struggled with it, so he approached one of his student-tutors for assistance. Thus, the student-tutor mediated Craig's ability to integrate the Quizzes function.

Craig was the only educator in the sample who taught predominantly on a chalkboard. He seemed to use Vula only because it was the norm for course organisation. Thus, it was unclear what Craig's outcomes to integration were.

5.8.2. Community and Division of Labour

Craig employed six student-tutors who resolved queries and guided students on problems. It was interesting that Craig only mentioned student-tutors explicitly in his experiences of community, suggesting that Craig was an independent educator. This was possible, as he had many years of teaching experience. Another possibility may be that his pedagogical approaches were in the minority at the department, thus reducing the likelihood of like-minded colleagues with whom to interact.

As a lecturer, Craig viewed his responsibility was to transfer knowledge to students. He did this via the chalkboard, taking care to “fa[ce] the class” in order to ensure students understood and to check for questions.

5.8.3. Rules and Norms: Teaching Engineering

Like others, Craig highlighted the importance of theory-in-practice in engineering. He emphasised the importance of “basics”, for instance, using the chalkboard to develop a diagram for water to demonstrate its development, pressure, and temperature. He wanted students to understand the theory instead of “rely[ing] on their memories”. When Craig asked his students for the amount of power required to boil one litre of water, they responded incorrectly, as their calculators provided an amount required for a power station. From this, Craig deduced that students relied too heavily on technologies. They did not have the adequate “basics” to apply critical thinking to the outcome.

This chapter presented the activity systems of each participant. In the next chapter, I will synthesise the above information to form a departmental activity system.

Chapter 6: Department Activity System

Based on the individual activity systems, this chapter will explore commonalities and contrasts in the data in an attempt to understand the enabling and inhibiting forces for education technology integration at the departmental level.

6.1. Subjects

The subjects were all engineering educators. They were described based on their user levels, attitudes, and perspectives on education technology integration.

6.1.1. Technological Use Levels

Participants were grouped into levels of technological use: novices, intermediates, and experts. Novices were those who used a minimum range of education technology, limited to tools widely used in, or actively promoted by, the university, such as Vula and Microsoft PowerPoint. Mia and Craig fell into the novice category, as they only mentioned the use of Vula functions. Intermediates occasionally incorporated education technologies beyond those officially supported by the institution. Keith and Dane were deemed to be intermediates, as they integrated YouTube videos, Google Meet, and 3D models. Experts made extensive and creative use of a variety of education technologies beyond those officially supported by the university, including third-party tools. Creative use was likely a result of experimentation with technology or computer playfulness. In TAM, computer playfulness contributes to perceived ease of use, ultimately influencing use behaviour via behavioural intention (Venkatesh & Bala, 2008:280). Expert users included Ted, Nick, Ryan, and Chad. Ryan made strategic use of the Wiley online textbook. Ted's use of GeoGebra changed the way he taught vector diagrams. Nick's repository of document camera videos helped streamline his pedagogical efforts. Chad's use of Backchannel altered in-class interactions. Except for Ryan, all expert users were fairly confident in their ability to master education technology for integration. All spoke positively about education technology.

Technological use levels also imply an element of quality, where advanced users demonstrated more independent integration of education technology.

6.1.2. Attitudes and Perspectives

The educators expressed a positive attitude towards, and believed in the importance of, education technology. This positivity could account for the resilience demonstrated by the novices. Despite Mia's online examination struggles and Craig's boiling water example, this has not resulted in the avoidance of educational technologies. Mia still hoped to explore alternative methods for her practical examination, and Craig encouraged his students to think critically about technology. Neither of them renounced education technology in their pedagogical efforts. In TAM, attitudes have a positive impact on behavioural intention, which impacts on technology use (Chuttur, 2009:10). Thus, the novices' positive attitudes motivated their behavioural intention and technology use despite their struggles.

Various perspectives could be inferred from the data to account for integration efforts. A perspective shared by most of the educators was the importance of "building blocks", as engineering is a difficult subject to grasp. This has manifested in the integration of resources such as videos, 3D models, and physical artefacts that help to visualise complex concepts.

In addition to guest presentations by industry-based speakers, educators incorporated tools commonly used by practising engineers such as Slack, GeoGebra, Mathcad, and Mathematica. This was because the educators thought it beneficial for students to be exposed to elements of their professional setting.

Some educators believed that students should be agents of their academic journeys. This manifested in the integration of technologies that enabled student agency. This included Chad's early use of Camtasia and later use of lecture recording. He also integrated Backchannel to encourage students to ask questions. Mia's use of Vula's Lessons function was intended to place information in students' hands.

Education technology was described as expediting certain responsibilities. Ryan used diagrams from the propriety online textbook resource so he did not need to create his own. Mathcad and Mathematica made grading and report writing easier for Ted. Of note were Vula's functions: the Q&A function helped to ease repetitive queries, and the Assignment function helped Nick to track timely submissions.

6.2. Object and Outcomes

The object of this study was education technology integration. By examining its instances among the educators, I was able to identify the outcomes of education technology integration.

Table 4 shows that educators integrated technologies that provided pedagogical value in terms of conveying theory and practical demonstrations. They also integrated technologies for interaction with students. Vula is the widely accepted education technology at the university.

Vula was used mainly for administrative and organisation functions among this group of educators (see Table 4). This is understandable, considering UCT is a residential institution, where face-to-face classes are the norm. However, Vula was used for interaction, via the Q&A function, to resolve common queries, suggesting its potential as an interactive pedagogical tool.

All the educators used institutional technologies. This is unsurprising, as students expect this of educators. Students are informed of the importance of institutional technologies during first-year orientation (Hutchings & Stent, 2014). From there, it seemed that educators integrated other education technology groups that assisted with their pedagogical goals. Thus, institutional technologies served as a platform for other education technologies. For example, the document camera (institutional technology) ensures that the pedagogical demonstration of a mini trebuchet (engineering technology) is accessible to all. Similarly, lecture recording (institutional technology), or a video (other technology) played in-class enables pedagogical demonstration of engineering concepts. This integration between education technology groups makes sense as institutional technologies perform at the university level, which means that it does not serve only the engineering discipline.

One outcome of education technology integration was to improve practical demonstration of engineering concepts. Science and mathematics-based subjects, such as those offered in an engineering degree, have traditionally been difficult to offer online due to the need for practical components (Martínez-Caro & Campuzano-Bolarín, 2011:474). This manifested in integration of education technologies that allowed educators to make complex theory visible, such as the use of engineering technologies and videos.

Another outcome was the preparation of engineering graduates for the workplace. This was demonstrated by Ted, who exposed his students to various engineering technologies (e.g., Slack, Mathcad, and Mathematica). This suggests that departments can help prepare graduates' technology integration in the workplace (overcoming first-order barriers) by incorporating discipline-specific technologies in the curriculum. First-order barriers, such as digital literacy skills, are of concern in South Africa (Ng'ambi et al., 2016).

Educators' many responsibilities resulted in efforts to streamline and simplify tasks, such as Vula's Q&A function, which avoided repetitive student queries. Thus, another integration outcome was the improved efficiency of certain tasks.

Table 4: Instances of Education Technology Integration

		Education Technology Function							
Education Technology Group	Education Technology Type	Organisation	Administration	Interaction	Enrichment	Pedagogical - theory explanation	Pedagogical - practical demonstration	Total Users per Type	Total Users per Group
Institutional Technologies	Vula	R, K, D, M	R, N, C1, D, C2	N, M, K				7	8
	CILT training resources				C1, M			2	
	UCT Libraries training resources				T			1	
	Document camera						N, C1	2	
	Microsoft PowerPoint					R, C1, K, D		4	
	Lecture recording					D, T, C1, R	D, T, C1, R	4	
Engineering Technologies	Engineering artefacts e.g. mini trebuchet, 3D models						D, R	2	3
	GeoGebra						T	1	
	Mathcad & Mathematica		T					1	
	Slack	T		T				1	
Other Technologies	Camtasia					C1		1	4
	Videos						C1, K	2	
	Proprietary resources e.g. online textbook					R	R	1	
	Google apps e.g. docs, meet, spreadsheet		N	R, K				3	
	Backchannel			C1				1	
Total Education Technologies per Function		2	3	4	2	4	6		

C1 = Chad; R = Ryan; M = Mia; T = Ted; N = Nick; D = Dane; K = Keith; C2 = Craig

Technological use levels: Novice, Intermediate, Expert

6.3. Mediating Tools

This node explores mediating tools found in the data which were "artefacts, social others, and prior knowledge that contribute[d] to the subject's mediated action experiences within the activity" (Yamagata-Lynch, 2010:16). Mediating tools enabled subjects to achieve the object.

6.3.1. TPACK

TPACK and its elements served as a mediating tool for some of the educators. Ryan's TPACK contributed to his assessment of the appropriate education technology to integrate. Nick's integration was dominated by TCK and TPK, to find the appropriate technology and to promote exploration into other technologies.

Educators' prior experiences also contributed to their TPACK. Chad was an educator for over 20 years. As an expert user, his pedagogical experience contributed to his TPACK, integrating more types of education technologies than anyone else in the group. Ted's mastery of engineering technologies over time contributed to his TPACK via his TCK, mediating his choice in education technologies.

The educators who displayed substantial TPACK in their interviews were all identified as expert users, undertaking complex and creative education technology integration.

6.3.2. Pre-existing Infrastructure

All educators integrated institutional technologies. This was enabled by UCT's infrastructure, such as the reliable Eduroam Wi-Fi setup and UCT's early efforts to integrate a LMS, Vula. These provisions are so ingrained in the UCT experience that none of the educators noted them explicitly as an enabling factor. However, it is this infrastructure that provided the educators' access to institutional technologies such as Vula and lecture recording facilities. Access paired with autonomy promotes education technology integration (Ertmer, 2005:25). Thus, education technology integration was mediated both by UCT's infrastructure and the educators' access to institutional technologies.

6.3.3. Mediators

In some cases, students informed integration decisions, serving as mediators for the educators' efforts. Ryan intended to integrate a video shared by his student. Students' feedback helped to adapt both Dane and Mia's integration efforts.

Students' level of study may have mediated the choice of technology, as all the educators had a combination of postgraduate and undergraduate responsibilities. Educators' integration choices for postgraduate students were centred on interactions. Ted used Slack for improved interaction and organisation of the supervisory relationship. Nick encouraged his postgraduate students to contact him using his mobile number in cases of emergencies. Contrast this with education technology used in the undergraduate space, which served a more unidirectional pedagogical function, e.g., Microsoft PowerPoint, videos, and engineering tools.

Some participants acted as mediators for others' integration in the department. Ted identified as the advocate for technology in the department. Chad's leadership roles in the department and faculty gave him the confidence to explore unique technologies, such as Backchannel. That confidence likely mediated his colleagues' willingness to try and adopt Backchannel into their classrooms. As an academic development lecturer, Ryan had a better view of the integration practices in the department, as he was invited by colleagues to provide feedback on their teaching practices. Thus, Ryan's feedback likely mediated others' integration efforts.

There were also support services at the university level that mediated education technology integration, including CILT, UCT Libraries, the Vula team, and ICTS. CILT provided resources on teaching and learning. UCT Libraries provided training that helped to improve digital literacies. The Vula team assisted with queries from Vula site owners. ICTS provided classroom support such as hardware setup.

6.4. Communities

Figure 15 depicts a diverse network of role-players who impacted educators' education technology integration. The role-players are colour-coded and grouped into three communities: departmental, university and external. Descriptions for each community are given below.

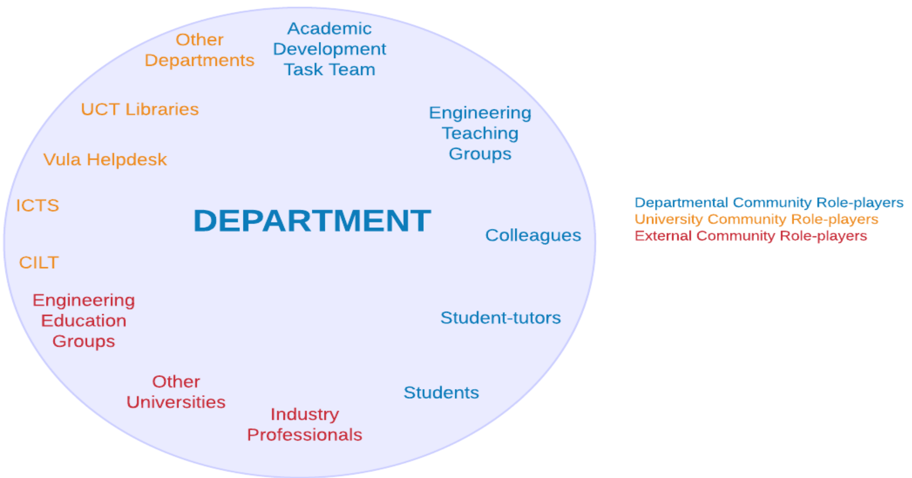


Figure 14: Community Node

6.4.1. Departmental Community

The departmental community constituted the most role-players. Student-tutors sometimes assisted with integration, such as with Craig's use of the Quizzes function on Vula. Students' feedback informed educators' education technology integration, as was the case with Mia. At times, students also provided resources, such as Ryan's student, who shared a video that Ryan planned to integrate in future.

This community also consisted of colleagues and other formalised groups, such as the Education Teaching Group and the Academic Development Task Team, which guided pedagogical efforts.

In terms of colleagues, there seemed to be mixed opinions. Colleagues were at times sources of inspiration (e.g., Ryan's observation of the "really good stuff" his colleagues were implementing) or frustration (e.g., Nick's "luddites"). Although there have been collaboration efforts, they were either unsustainable (e.g., Ryan's seminars), or educators did not attend (e.g., Keith's non-attendance at monthly discussions). Dane observed that educators had too much autonomy, as collaborative ideas lacked enforcement. Chad stated that it was atypical for colleagues to provide feedback voluntarily. Yet, there were individuals like Ted, the self-described technology advocate in the department, who offered suggestions to colleagues. This suggests that there may be those who want more collaboration and those who do not or may not need it.

Colleagues' influence on education technology integration did not seem systematised. Many educators in this group were capable of using, and had positive attitudes towards, education technology. Thus, they may have not seen the need to form a collaborative community. Still, members of this group may serve as models to encourage integration in others.

6.4.2. University Community

The university community consisted largely of support role-players. These included UCT Libraries, the Vula team, CILT, and ICTS. Their responsibility included assisting with education technology integration queries. However, in the case of Mia, she did not receive the assistance required, thus tainting her view of support role-players. Others, such as Chad and Nick, had relatively positive experiences. Interestingly, these support role-players were engaged by fewer than half of the participants. One reason may be a lack of awareness, which points to the need for better communication from these groups. Another reason may be that these educators were able to acquire the skills on their own, thus they did not find the need for support.

Educators in other departments played a role in the university community. They served as sources of inspiration and benefactors of integration efforts. For example, Ted's integration of auto-marking tools inspired by his observation of their use in the Computer Science Department.

6.4.3. External Community

This included industry professionals who acted as guest speakers or mentors. These interactions were deemed beneficial for students and, at times, served as a source of motivation for integration. For example, when industry professionals were unable to meet in person, Keith set up Google Meet sessions for his students.

Other universities provided inspiration and resources into integration and pedagogical efforts. Although this was not stated explicitly in interviews, some of the participants were linked to national engineering education groups. In general, the external community encouraged education technology integration through information-sharing.

6.4.4. Synthesis

In terms of the community node, interviewees seemed to find inspiration for technology integration from a wide range of sources. Some indicated that they learned from their students. Some looked to other departments and even to other universities. In contrast, few references were made to formalised departmental groups or support role-players at the university level. It was strange that not more educators were drawn to these groups for inspiration on education technology integration. I conjecture three possible explanations based on the data.

These educators were all relatively confident and capable in their integration efforts. Their self-sufficiency decreased the likelihood that they would reach out to support structures. Such as CILT, for integration assistance. This department also had representation on the university's engineering education research group, likely contributing to their self-sufficient attitudes.

Secondly, the educators' workload was often varied, heavy, and mundane. For example, both Mia and Ted were completing their PhDs, which created additional workload. Ted also assisted on the Academic Development Task Team spinoff group. Nick was a course convenor, which had added administrative responsibilities. Thus, possibly for efficiency purposes, educators welcomed integration ideas from easily accessible role-players, such as student-tutors.

Lastly, a formalised, collaborative culture of education technology integration seemed to be lacking in the department. I refer specifically to "formalised" collaboration, as there were instances of informal collaboration (e.g., Ted's lessons on GeoGebra to his colleagues). Informal collaboration may not be widely shared, and thus runs the risk of alienating others. This may account for some of Mia's experiences. Mia joined the department two years before data collection. Thus, if informal collaboration was the norm in some groups, Mia may not have been inducted into them yet. This may explain her thin community node which consisted mostly of university community role-players.

When formalised collaborative efforts were made (e.g., Ryan's seminars), they were unsustainable. This likely resulted in the various bottom-up approaches shown in the data. This points to the need for leadership intervention. Leaders who drive technological plans and possess a shared vision with staff encourage education technology integration (Buabeng-Andoh, 2012) and enable staff empowerment (Tondeur et al., 2011).

6.5. Division of Labour

Division of labour is concerned with the distribution of work in an activity system and how this impacts the object (Yamagata-Lynch, 2010:23).

6.5.1. Educators

Departmental leadership seemed uninvolved in integration practices, as the educators had autonomy to integrate education technology. This resulted in a range of integration efforts among the interviewees, from Chad, who went beyond institutional tools, using Backchannel; to Craig, who only used Vula for minimal administrative purposes. Regardless of the extent of integration, all educators understood the value of technology.

It was interesting to observe how leadership may have impacted integration in the community node versus this node. In the former, leadership's lack of directiveness hindered collaboration. Whereas in this node, it indirectly provided space for autonomy. Tondeur et al. (2011) found that supportive leadership is more suited to pre-service educators. Considering half of the participants were expert users, they were more able to navigate integration efforts on their own.

Educators in the study focused their integration efforts on undergraduate teaching. As part of this, Vula course organisation and administration emerged as a core responsibility for many educators. Interestingly, administrative duties are traditionally the responsibility of administrators at UCT. This phenomenon was motivated by a desire for efficiency, quality control, and positive reinforcement. Dane believed that going through an administrator would take longer, thus he preferred to do it himself. Chad explained that it was important for “quality control” and “taking ownership”. Ryan was motivated by positive reinforcement, as students expressed that they were “really happy” with his course organisation.

This voluntary assumption of Vula administrative duties may be due to the view that efficient and accessible course administration was essential to students. This was shown in educators such as Mia and Ryan, who valued student feedback on such matters. This may be further exacerbated by the fact that class attendance is optional, as noted by Chad, thus organisation of administrative matters becomes integral to students’ academic experience.

6.5.2. Student-tutors

All educators mentioned the important role of student-tutors in their interviews. Student-tutors alleviated repetitive tasks, such as grading assignments and responding to student queries. Student-tutors may have contributed to integration efforts by providing educators the free time and cognitive space to make such decisions.

6.5.3. Support Services

Support services identified in the data included UCT Libraries, ICTS, CILT, and the Vula team. UCT Libraries offered courses that enhanced digital literacies. ICTS provided hardware setup support in classrooms. They were also responsible for the set-up of lecture recording venues. CILT served a developmental purpose for educators via the provision of various pedagogical resources. The Vula team supported both students and educators on the use of the university’s learning management system.

Ultimately, the educators were responsible for education technology integration, but these services enabled the process.

6.5.4. Other Groups

Other groups that may have impacted education technology integration were the Academic Development Task Team and the engineering teaching groups. The former is concerned with pedagogical strategies that aid in student throughput. The latter are national groups focused on the production of knowledge and strategies related to engineering education.

Association with these groups likely benefited educators' integration efforts. This was shown partially in the technological use levels of educators who were connected to these groups. Ryan and Ted were both on the Academic Development Task Team; they were identified as expert users of education technology. Another expert user, Chad, was also involved in such groups due to his leadership history in the department.

6.6. Rules and Norms

This node discusses formal and informal regulations that guide the subject's behaviour to attain the object (Yamagata-Lynch, 2010:23).

6.6.1. Becoming an Educator

There is an expectation for educators to have a certain level of technical competency and computer self-efficacy, likely due to the increased integration of technology inside and outside of the classroom (e.g., Vula, Microsoft PowerPoint, email, etc.). Anchored in perceived ease of use, computer self-efficacy enables technology use through behavioural intention (Venkatesh & Bala, 2008:280). Thus, all the educators had some interaction with education technology integration in their pedagogical efforts. Yet, autonomy has resulted in differing manifestations of education technology integration. Ted sits on one end of the spectrum: as a technology advocate, he regularly integrates multiple forms of technology. This compared to Craig, who prefers chalkboard, and is cautious about students' reliance on technology.

Despite the expectation of tech-savviness, the varied manifestations of education technology integration make it unclear what the standard of technical ability should be. This could be misleading or intimidating for those seeking a career in the department.

6.6.2. Teaching Engineering

There were no rules concerning education technology integration in the department. This autonomy gave rise to a variety of education technology integration in the data. The relationship between autonomy and integration was explored by Ertmer (2005:25), who found teachers with access and autonomy to integrate technology into their curriculum were more likely to do so.

Six of the educators spoke about the challenges of pursuing an engineering degree. Their concerns centred on engineering as a discipline that required "building blocks". The workload in engineering was accumulative, making it difficult for students who fall behind. There was an emphasis on students' ability to have a good grasp of the theory and its applications. As such, many education technology integration efforts were geared towards resources that could demonstrate theory visually, for example, teaching vector diagrams via animations and showing videos that visualised abstract concepts or complex machinery.

6.6.2.1. Lecture Recording

With lecture recording becoming the default in enabled classrooms, an institutional rule regarding class attendance changed from students "must attend" all classes (UCT, 2017a:8) to students "are expected to attend" all classes (UCT, 2018a:8).

Half of the educators (Ted, Ryan, Chad, and Dane) spoke about lecture recording. All noticed its impact on attendance. Ted thought this as normal and did not mind it, but he mentioned colleagues who considered opting-out if attendance dropped below two-thirds. Ryan accepted the absenteeism reluctantly. Chad suggested that educators should make it worthwhile for students to attend. Dane was the only educator in the group who opted-out, despite his awareness of the institution's push for it. Lecture recording is a complex issue at UCT, where educators' discomforts may impact the sustainability of this institutional change.

6.6.3. Challenges for Students

Students tend to underestimate the work required to obtain an engineering degree. This is complicated by the imbalance of credit-to-workload ratio, as it gives students the wrong impression of the effort required to succeed in the programme. Students end up spending more time than expected, as observed by Ryan.

While technology may help students learn, some educators worried that students may abuse technology. Nick feared that students memorised textbook solutions instead of understanding them. Craig worried that students would use technology as a crutch, rather than developing foundational knowledge. Such fears may constrain educators' decision to integrate education technology.

Some educators argue that academia creates an unrealistic environment for students in relation to industry. For Mia, summative assessments were not a true reflection of students' capabilities. In reality, students would have access to the necessary resources for problem-solving. Ted's insistence of exposing students to engineering technologies, and his qualm over the dominance of manual calculations, also indicated the misalignment between the curriculum and industry preferences.

Based on the discussions in this chapter, Figure 16 provides the activity system of education technology integration as represented by the sample.

This chapter discussed the departmental activity system synthesised from the data in Chapter 5. In the next and final chapter of this dissertation, I will address my research questions and provide recommendations for future research.

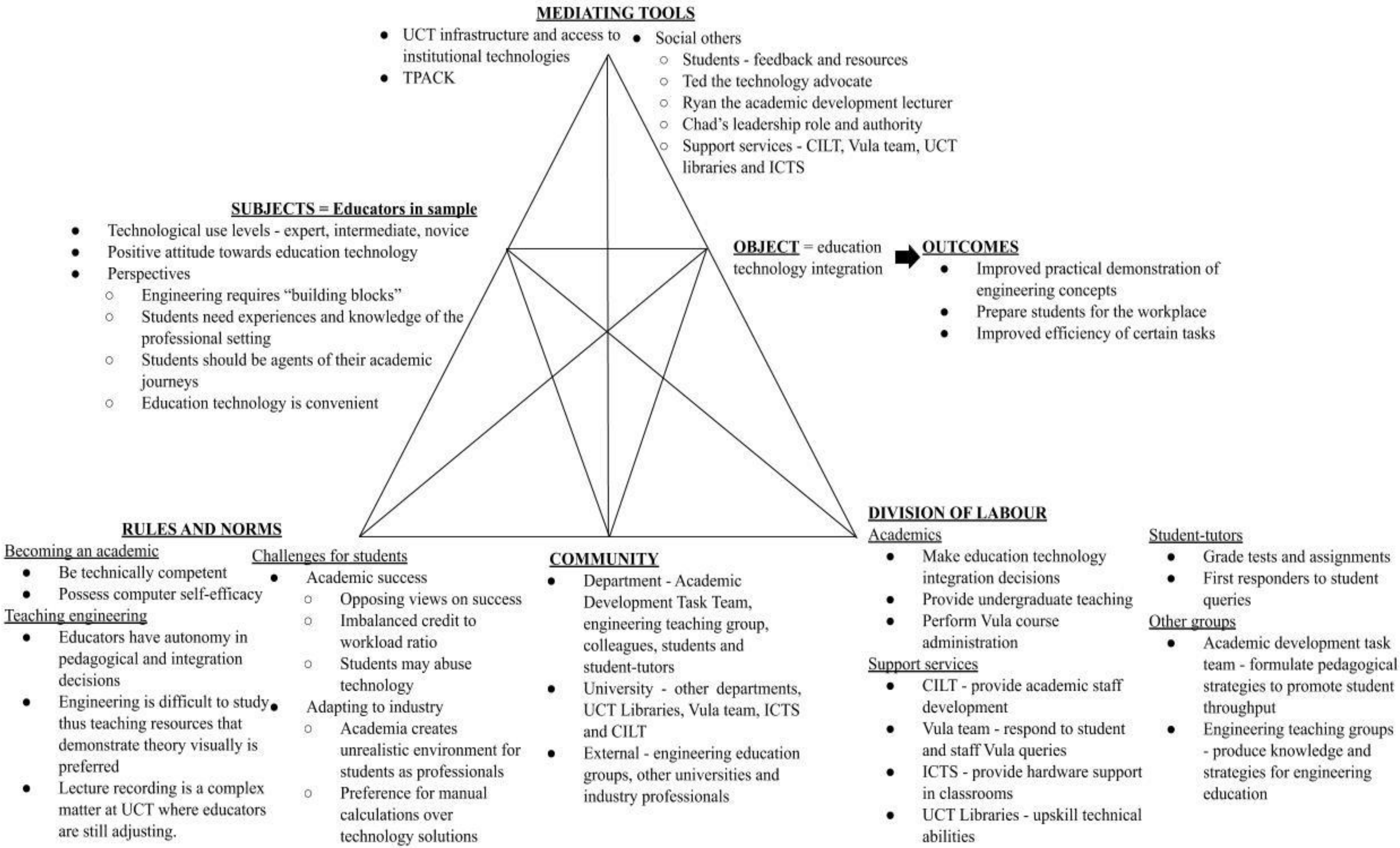


Figure 15: Department Activity System

Chapter 7: Conclusion

This research contributes to understanding education technology integration in the Engineering Faculty at UCT by addressing the following questions:

- What education technologies have been integrated by engineering educators?
- Why do engineering educators integrate education technology?
- What conditions enable engineering educators' education technology integration?
- What conditions constrain engineering educators' education technology integration?

A qualitative case study with an interpretivist approach was adopted to investigate the above. Semi-structured interviews were conducted with eight educators in an engineering department. These interviews were transcribed and analysed using CHAT's nodes as main themes. CHAT was selected as the theoretical model for its consideration of context and complexity. Analysis was done on the individual level and, thereafter, compiled into a composite activity system for this group of educators.

7.1. Summary of Findings

As all educators integrated education technology, they were grouped into different technological use levels: experts, intermediates, and novices. All educators also expressed a positive attitude towards education technology.

7.1.1. Education Technologies Integrated

All participants integrated institutionally-supported technologies, with Vula being the most commonly used. Half of the participants used other technologies such as Google applications and videos. Some educators integrated programmes such as GeoGebra and Slack.

Institutional technologies served as the "starter-kit" for integration at UCT, as all educators had access to, and were aware of, these technologies. From there onwards, educators explored other technologies, depending on their needs. This accounted for the variety of technologies found in the data. It was the expert users who tended to integrate a variety of education technologies beyond those officially supported by UCT.

7.1.2. Reasons for Integration

Participants integrated education technology for various reasons. One was to provide practical demonstrations of engineering concepts. Teaching resources that demonstrated theory visually were preferred. These included videos and document cameras that displayed engineering artefacts.

Another outcome was to prepare students for industry, evidenced by exposure to engineering technologies such as Slack, Mathcad, and Mathematica.

Educators also praised the convenience and efficiency afforded by education technology. Most notable was the various uses of Vula functions: Q&A to reduce repetitive queries; Assignments to monitor timely submissions; and Gradebook to record student results. Another example of efficiency included Google Spreadsheets for version control purposes when grading papers alongside student-tutors.

7.1.3. Enabling and Constraining Conditions

CHAT's mediating tools and contextual nodes highlighted enabling and constraining conditions that affect education technology integration.

A dominant enabling condition was UCT's infrastructure. With a secure Wi-Fi network via Eduroam and various support entities such as CILT (pedagogical support), ICTS (technical support), and the Vula team (LMS support), the university was able to provide a selection of easily-accessible education technologies. Initiatives such as the Laptop Project ensured that even financially-constrained students benefit from integration efforts. Infrastructure was identified as a major mediating tool in the literature (e.g. Buabeng-Andoh, 2012; Demir & Yurdugül, 2015; Ertmer, 2005; Georgina & Olson, 2008; Keramati et al., 2011; Pathiratne, 2014; Tarvid, 2008; Tondeur et al., 2011; Unwin et al., 2010).

Other dominant enabling conditions were technical, pedagogic, and content knowledge. Educators who displayed complex and creative education technology integration drew on their substantial TPACK and were identified as experts. Some of these educators enabled integration in the department due to their roles (Ryan the academic development lecturer, Chad's strategic positions) and reputation (Ted the technology advocate). These individuals either were able to provide feedback or had technical knowledge of various tools to share with colleagues.

Students enabled integration by providing educators with feedback. Some even provided resources, which educators planned to integrate in future classrooms. Student-tutors enabled integration indirectly by alleviating educators' workloads so that they would have more time to explore integration.

One aspect that may constrain educators' technology selection was the fear that students abused technology. As engineering was a discipline of application, Nick feared students regurgitated solutions from downloaded memoranda rather than demonstrated understanding. Craig was weary of students' reliance on technology, as many failed to evaluate critically the feasibility of a calculated solution.

Not all participants agreed on what constituted enabling and constraining conditions. Two instances from the data were perceived, by some, to be enabling integration, and by others, to be constraining integration.

Educators at UCT have autonomy over their pedagogical choices. The relationship between autonomy and integration was explored by Ertmer (2005:25), who found teachers with access and autonomy to integrate technology into their curriculum were more likely to do so. In this study, autonomy accounts for the variety of technologies integrated. However, this diversity of choice may limit opportunities for collaboration among staff, reducing effective integration. Although informal collaboration exists, this could result in excluding members new to the department. While autonomy may be an enabling condition for some, it is likely to hinder integration efforts for struggling educators.

One choice of education technology integration, lecture recording, generated contrasting positions. As a default opt-in for equipped classrooms, it enabled education technology integration without effort from the educators. Although convenient, a decline in attendance was observed by many educators in the group. Ted noticed colleagues opting-out of lecture recording if attendance dropped below two-thirds. The infrastructure for lecture recording enables effortless integration, but students' abuse via non-attendance threatens face-to-face practices which may impact on the longevity of the technology.

7.2. Reflections

From the data and my approach to the topic, education technology integration was highly dependent on the context and agency of individuals. Instances of integration were a result of departmental autonomy and educators' reasons for integration, which were subsequently either constrained or enabled by their interactions with the environment.

In my quest to understand how UCT educators in an engineering department integrate education technologies into their teaching practice, the CHAT framework has provided insights into the answer. Of particular value were the context nodes, which helped to explore the richness expected by interpretivist research. CHAT provided a framework for initial exploration; other concepts were needed to understand the data on a deeper level. Thus, I incorporated elements from TAM and TPACK. TAM provided a theoretical basis to some of the concepts inferred from the data (e.g., computer self-efficacy). TPACK was invaluable in understanding educators' capacity for implementing integration.

7.3. Limitations and Future Recommendations

I mentioned that my study provided a glimpse into understanding integration in the department. This is because of the limitations in any research.

Firstly, participants in the study had positive attitudes towards education technology integration. This may have resulted in an unbalanced representation of education technology integration in the department. Future research may benefit from identification of users with less positive attitudes or who prefer more traditional tools of pedagogy. The inclusion of these persons would provide a more comprehensive understanding of education technology integration in the department.

There were particular individuals in this department who mediated others' abilities to integrate education technology. Integration projects may benefit from identifying key individuals in a department to promote education technology integration.

Interestingly, educators who displayed substantial TPACK were also expert users in the group. This suggests TPACK as an indicator of complex and creative education technology integration. Future research may wish to explore this connection.

The educators mentioned support role-players in the university community. However, as this sample consisted of proficient integrators, little was gathered about the specifics of the support role-players. Future research may investigate the effectiveness of support role-players among less self-sufficient educators to understand first-order barriers which includes adequate infrastructure and support (Kim et al., 2013). Of particular interest may be the fact that technical support was identified as a common barrier in South African ICT integration efforts (Sherman & Howard, 2012:2099). Moreover, support role-players are imperative in order to foster an environment for education technology integration (Adeyelure & Kalema, 2019; Buabeng-Andoh, 2012; Georgina & Olson, 2008; Gudmundsdóttir, 2010; Inan & Lowther, 2010; Ruggiero & Mong, 2015; Tsai & Chai, 2012).

The impact of leadership in the community node versus the division of labour node was a point of interest in this study. In the former, leadership seemed lacking in terms of fostering collaboration. In the latter, a lack of leadership seemed unintentionally beneficial for this group of educators, as it enabled autonomy in integration. This highlights the value of understanding further the role of leadership in education technology integration in the department.

Lastly, future research could explore the contradictions in the activity system. Contradictions are emergent disturbances in the activity system necessary for change and the development of the activity system. From the data, there were suggestions of contradictions such as the approach to collaboration among colleagues in the department and the contrasting positions expressed towards lecture recording. The examination of contradictions leads to possible interventions via the change laboratory process to improve education technology integration in the department.

7.4. Closing

At the time I conclude this dissertation, it is the year 2020, and the world is battling COVID-19. When I started on this journey in 2017, I did not foresee how higher education's reliance on education technology would happen so dramatically. Although I always believed in its value, I never expected to live in a time in which the status quo of traditional higher education institutions would change so drastically. Now, education technology has become an integral part of pedagogy, with educators around the globe still learning how to adapt to teaching online. As I reflect on the contribution of my study, I believe that understanding how educators integrate education technologies (be it engineering or other disciplines) has, since the inception of this topic, increased in significance. When we emerge on the other side with vaccines in hand, the impact of education technology will likely bring about a new equilibrium in higher education spaces. It is my sincere hope that this minor dissertation has contributed in some way towards improving educational experiences.

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Appendix 1: Ethical Clearance

SCHOOL OF EDUCATION

Professor Azeem Badroodien

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Level 5, Neville Alexander Building, University South Avenue, Upper Campus
Tel: +27 (0) 21 650 2774 Fax: +27 (0) 21 650 3489
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Clearance number: EDNREC20180601 25th June 2018

Mrs Ka Wai May Cawood

M.Ed Program

University of Cape Town

Re: Ethical Clearance for Research Project

Dear Mrs Cawood

I am pleased to inform you that ethical clearance has been granted by the School of Education Ethics Review Committee of the Faculty of Humanities for your M.Ed research project entitled: *Exploring Readiness for Blended Learning Among Academics in an Engineering Department*

We wish you all the best with your study.

Yours sincerely,

Signature Removed

Prof Azeem Badroodien
Chair School of Education Research Ethics Committee

Appendix 2: Consent Form

CONSENT TO PARTICIPATE IN RESEARCH

Exploring Readiness for Blended Learning among Academics in an Engineering Department[1]

You are invited to participate in a research study conducted by myself, Ka Wai Cawood (MEd specialising in Educational Technology student) under the supervision of A/Prof Jeff Jawitz and Ms Shanali Govender, academics in the Centre for Innovation in Learning and Teaching at UCT. The results of this study will contribute to a dissertation for the attainment of a Master's degree with the School of Education at UCT. The modern shift towards a technological focus in the classroom has brought forth various blended practices. We therefore invite you to participate in this study to provide your insights and experiences with blended learning in your teaching practices.

PURPOSE OF THE STUDY

The purpose of the current study is to explore readiness for blended learning amongst academics in an engineering department.

PROCEDURES

If you volunteer to participate in this study, I will arrange a convenient date and time to meet with you. Your participation will consist of an approximately one hour audio recorded interview that will be conducted in a private room on campus. During the interview, I will ask you to share your experiences of using online resources and /or a blended learning design with your classes or courses.

CONFIDENTIALITY

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. Confidentiality will be safeguarded in the following ways:

- Only the researcher and her supervisors will have access to transcripts and audio recordings of the interviews.
- Electronic versions of transcripts and recordings will be safeguarded with a 2 step authentication process.
- Your name and personal details will not be indicated on your interview transcriptions. Nobody, except the researcher, will be able to link your name to what you said in the interview.
- Confidentiality will be ensured by substituting your name with a pseudonym.
- Please note that you have the right to make changes to or to refuse permission to use the data you provide.

PARTICIPATION AND WITHDRAWAL

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any

[1] Title has changed since data collection. Current title is: Understanding Education Technology Integration Experiences among Engineering Educators: A Cultural Historical Activity Theory Approach.

questions you do not want to answer and still remain in the study. The investigator may withdraw you from this research if circumstances arise which warrant doing so.

Should you experience discomfort for which you may need assistance during or after the completion of the interview, support can be found at http://www.hr.uct.ac.za/hr/benefits/org_health/counselling

IDENTIFICATION OF INVESTIGATORS

If you have any questions or concerns about the research, please feel free to contact:

Principal Investigator: Mrs Ka Wai Cawood E-mail: kawaimay@gmail.com Contact no.: 021 650 4493	**Main Supervisor:** A/Prof Jeff Jawitz Email: jeff.jawitz@uct.ac.za	**Co-Supervisor:** Ms Shanali Govender Email: shanali.govender@uct.ac.za

RIGHTS OF RESEARCH SUBJECTS

You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study.

SIGNATURE OF RESEARCH SUBJECT

The information above was described to me by Mrs Ka Wai Cawood. I was given the opportunity to ask questions and these questions were answered to my satisfaction.

I hereby consent voluntarily to participate in this study. I have been given a copy of this form.

____

Name of Subject/Participant

____ ____________________

Signature of Subject/Participant **Date**

SIGNATURE OF INVESTIGATOR

I declare that I explained the information given in this document to ______________________________ [*name of the subject / participant]*. S/he was encouraged and given ample time to ask me any questions. This conversation was conducted in English.

____ _________________________

Signature of Investigator **Date**

Appendix 3: Interview Schedule

Hello, my name is Ka Wai. As you may have read on the consent form from my email, I am pursuing my Masters in Education in Educational Technology. I am also currently working at the university as an End User Support Officer with Student Systems Support based on Middle Campus.

Today I will be interviewing you with regards to your experiences with information technology integration in the last few years. Through this process, I am hoping to gain an understanding as to your department's capacity for information technology integration.

Before we begin, I have printed hard copies of the consent form for you. Do you have any questions regarding this?

[Question and answer with participant regarding consent form. If no questions from participant, just briefly go through consent form. Participant signs form.]

Thank you very much for the form. We will now begin the interview. Please note there are no right or wrong answers for these questions and that my role here is to ensure I understand your experiences with blended learning. I will only be asking follow up questions for clarification purposes. If at any point, you feel uncomfortable in the discussion, please let me know.

When we are done, your interview will be transcribed verbatim. However, any identifying information will be coded e.g. your name will be replaced with a fictitious name / course codes will be replaced with generalised course names.

Guiding question	**Underlying question (corresponding CHAT node)**	**Relevant Research Question**
What is your current position at the department? What are the typical responsibilities of that position? Could you tell me about the course/s you teach on?	Background information on participant (subject)	
Have you ever used online resources / technology in your teaching? When? How?	• What do you understand by blended learning? (object outcomes) • How have you implemented blended learning practices? Could you provide some examples? (mediating tools)	• What education technologies have been integrated by engineering educators? • Why do engineering educators integrate education technology?
What happened (when you used online resources / technology)?	• What helped or didn't help during this process? (community / rules and norms / division of labour) • Were there any formalised / informal guidance with regards to implementing blended learning in	• What conditions enable engineering educators' education technology integration?

Guiding question	**Underlying question (corresponding CHAT node)**	**Relevant Research Question**
Follow up with probing/clarification questions, such as: • So did you have help? • What inspired you to do this? • What made this easy or difficult? • What did you use the tech for? • How did you figure that out? • What did everyone think when you did that? • Did people like what you were doing? What were other people doing? • What did this feel like? • Would you do this again? • Would you try something different?	your workplace? (division of labour / rules and norms) • How have your colleagues responded to your efforts? (community)	• What conditions constrain engineering educators' education technology integration?
Has this changed what you do? How so? / Why not?	How has this experience impacted on your role in the department? (subject / division of labour)	
(For non-users) What gets in the way?	Why did blended learning not occur? (division of labour / rules and norms / community)	
How do you see the future of educational technologies and online learning in your field?	What is the participant's view on the sustainability of blended learning? (freeform question – code into node/s depending on response)	

Once again, thank you very much for your time. I really appreciate you taking time out of your busy schedule to support me in my studies.

A copy of the recording will be shared with you within 24 hours so that you may browse through it. If you feel there is anything further you would like to add or omit, please feel free to contact me via my details on the consent form. You are also welcome to contact me for any other information related to my study.

Thank you again and all the best!