First-Year Engineering Students' Use of Digital Technology for Learning: The Role of Agency

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Abstract

The use of digital technology has become integral for teaching and learning in engineering curricula at universities. However, in South Africa, many students enter their first year of study with limited prior access to and engagement with digital technologies for learning, which presents challenges for them and their educators. This paper is based on a PhD study that explores the student experience, specifically agency, when students use digital technologies for their coursework in first-year engineering. The key question posed in this study is "How do engineering students demonstrate agency when using digital technologies for their coursework?" The study drew on Cultural Historical Activity Theory as a systemic framing for analysing learning as a socially mediated, culturally situated activity, emphasizing the dynamic interactions between its tenets. An ethnographic approach, which entailed observations, focus groups, and individual interviews, was employed to collect data and answer the research question. By mapping the elements within activity systems, the study identifies contradictions such as mismatches between students' prior digital experiences and institutional expectations that catalyse learning. The findings show variation in agentic engagement and action by students as they developed their ability to use digital technologies for course activities. The study revealed how digital literacy is not merely acquired but co-constructed through participation in culturally and historically embedded practices where students took initiative to improve their digital skills, used adaptation strategies to sustain learning, and redefined the status quo in unfavourable circumstances.

Keywords: agency, digital technologies, first-year engineering student, contradictions

1 Introduction

Digital educational technologies have emerged as integral to the delivery of educational knowledge and skills in higher education. For engineering students, using digital technologies, including software applications, computing devices, and internet-based platforms, is no longer optional but essential. First-year engineering students are expected to engage with a range of digital technologies to access learning materials, participate in academic activities, and complete coursework. Central to this engagement is an institution's Learner Management System (LMS), which serves as the primary gateway for students to access course content, receive communication from lecturers, and access links to download discipline-specific software. The LMS thus functions not only as a repository of resources but also as a scaffold for students' initial encounters with the digital practices that underpin contemporary engineering education.

However, first-year engineering students in South Africa have different socio-economic backgrounds, varying levels of digital literacy, and prior access to technology and other digital skills (Naidoo & Raju, 2012). This is primarily due to the historical patterns of inequality created during the apartheid era (Jantjies, 2020; Mhlanga, 2020). South African institutions of higher learning adopted the use of digital technologies at a time when they were still emerging from the effects of apartheid. The legacy of apartheid education, marked by racially segregated access, limited resources, and exclusionary pedagogical practices, continues to shape the educational landscape (Mekoa, 2018). For the students transitioning from high school to South African universities, these challenges would have affected the quality of their digital skills, since many would not have had access to digital technologies (Jantjies, 2020; Khalid & Pedersen, 2016).

In addition, the challenges posed by the 'fees must fall' protests between 2015 and 2017 (Czerniewicz, 2020; Czerniewicz et al., 2019) as well as the COVID-19 pandemic (Lazar, 2021) accelerated the need for first-year engineering students to engage with digital technologies for online or blended learning. It has been argued that integrating activities that require the use of digital technologies in curricula may aid the development of these digital skills (Ganduri et al., 2021; Mian et al., 2020), however, many students still find themselves in learning environments without these skills.

Engineering students can benefit from digital technologies by gaining appropriate skills and competencies as an outcome of self-paced online and blended learning activities. However, these affordances do not emerge automatically but rather, rely on the agency of students who actively participate in them (Aagaard & Lund, 2020; Castro, 2019). This study drew on Cultural Historical Activity Theory as a systemic framing for analysing learning as a socially mediated, culturally situated activity, emphasizing the dynamic interactions between students (subjects), digital tools (mediating artifacts), institutional norms (rules), peer relationships (community), role of educators and support staff (division of labour) as well as the curricular expectations (object). It considers the relationality between technologies and student learning when considering how students mediate their learning with digital technologies and how they demonstrate agency throughout their first year of study.

2 Literature review

Agency refers to the capacity of individuals to act independently and make their own free choices (Archer, 1996). In the context of education, agency involves students' ability to influence their learning processes, make decisions about their educational paths, and engage actively in their academic environments. Students are said to have this kind of agency when they have gained the power to influence their learning, making choices about, and achieving their learning goals through the optimum use of digital technologies (Andresen, 2020)

Many researchers have carried out studies on agency where students learn face-to-face in classrooms including Archer and Archer (1996); Bandura (1989, 1999); Emirbayer and Mische (1998); and Giddens, (1984), while research on agency that is centred on digital educational technologies for learning is gaining traction (Bandura, 2002). Passey et al. (2018) introduced the term *digital agency* to describe an individual's capacity to navigate, control, and adapt within digital environments. They conceptualized digital agency as comprising three interrelated components: *digital competence*, *digital confidence*, and *digital accountability*. This framing of digital agency emphasizes not only the technical skills required to operate digital tools, but also the self-assurance to use them effectively, and the ethical responsibility associated with digital engagement. However, Stenalt (2021) critiques this conceptualization, arguing that it may oversimplify the complex socio-cultural dimensions of agency in digital learning contexts. Stenalt suggests that digital agency should be understood as a more fluid and context-dependent construct, emphasising relational, cultural, and technological dynamics (Stenalt, 2021) shaped by learners' interactions with institutional structures, pedagogical practices, and broader societal influences. She further suggests that the framework of agency should consist of "agentic possibility, digital self-representation, data uses, digital sociality, and digital temporality" (p.60) as critical domains. Aagaard and Lund (2020), also argued that agency is transformational as the usage of digital educational technologies is based on the culture of the users.

The study of agency in digital spaces must, according to Klemenčič (2017), be promoted because it has the potential to intervene in and influence engineering students' digital learning environments and learning skills. For example, Tamássy et al. (2023) examined how students and higher education institutions are portrayed in discourses at highly ranked business schools, and highlighted the roles and agency of students within these institutions, emphasizing how students navigated their educational environments and the influence of institutional practices on their agency. Similarly, Wong and Chiu (2021) explored the concept of the 'ideal' university student, focusing on the expectations and perceptions of students in higher education. The research discusses how these ideals shape student behaviour and agency, and the implications for educational practices and policies. Brod et al. (2023) provide an interdisciplinary review of agency in the use of educational technology, examining different perspectives on agency, including psychological, sociological, and technological frameworks, and discussing how these perspectives can inform learning design and improve educational outcomes by fostering student agency. Research on agency within digital learning environments is actively progressing at the University of Helsinki, focusing on transformative agency (Cornér, 2020; Kajamaa & Kumpulainen, 2019; Kumpulainen et al., 2018). Furthermore, scholars are examining the social dimensions of educational interactions as a means to foster student agency in digital education (Echenique et al., 2015; Jääskelä et al., 2017; Stenalt, 2020), where the research intersects with broader debates concerning the power embedded in the use of digital technologies, an area that remains highly contested. These ongoing debates include the question of whether technology controls the user, or whether the user shapes new technologies as they interact with them (la Cruz Paragas & Lin, 2016; Oliver, 2011; Selwyn, 2010).

Siddiq et al. (2023) highlight how a number of theoretical frameworks have been used to study agency. These include cultural-historical activity theory (CHAT) (Aagaard & Lund, 2020; Ganduri et al., 2023), studies building on Galperin's theory of orienting phases, and socio-cultural theory (Vygotsky, 1978b). Agency itself has been studied within CHAT through the principle of double stimulation (Sannino, 2015), transformative activist stance (Stetsenko, 2017) and relational agency (Edwards, 2005). However, this study approaches agency through the notion of contradictions (Engeström, 2001a).

3 Theoretical Framework

This study is framed by Cultural-Historical Activity Theory (CHAT or Activity Theory) (Engeström, 2001a; Vygotsky, 1978). CHAT provides the context for understanding human actions as an activity system (Leont'ev, 1978). An activity system is a unit of human activity composed of a subject, an object, mediating artifacts, community, rules, and the division of labour (Engeström, 1987). CHAT emphasizes the idea that the use of cultural tools and symbols, in this case, digital technologies, serves as a foundation for self-consciousness and is an unavoidable starting point in the process of becoming a human being. In other words, it suggests that people are not born as agentive beings; rather, they gain agency through participation in social activities such as education. Development that occurs amongst students is a result of the process of becoming a subject capable of agency, that is, capable of contributing to, influencing, and changing the environment as well as the social and material circumstances in which the person lives (Bozhovich, 2004; Holland & Lachicotte, 2007; Vygotsky, 1978a).

Vygotsky (1978) developed Cultural-Historical Activity Theory in the 1920s and early 1930s, and Leont'ev, Vygotsky's colleague, expanded on it from 1978 to 1981. The theory has since evolved over four generations of research (Engeström, 1996). Engeström (2001a) describes how it was the first-generation CHAT that developed Vygotsky's idea of human activity being mediated by tools. This idea of "cultural mediation" of actions is represented by a triad of subject, object, and mediating artifacts and is shown in Figure 1.

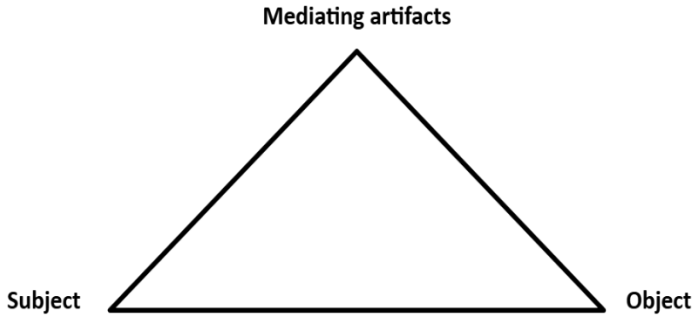

Figure 1 First Generation activity system (Engeström, 2001a)

The use of cultural mediating artifacts suggests that a society can no longer be described apart from its culture, and the study of its systems is hinged on the agency of the individuals involved. The second generation CHAT, shown in Figure 2, was introduced to highlight the relationships among subject, mediating artifacts, object, community, rules, and division of labour (Engeström, 2001a).

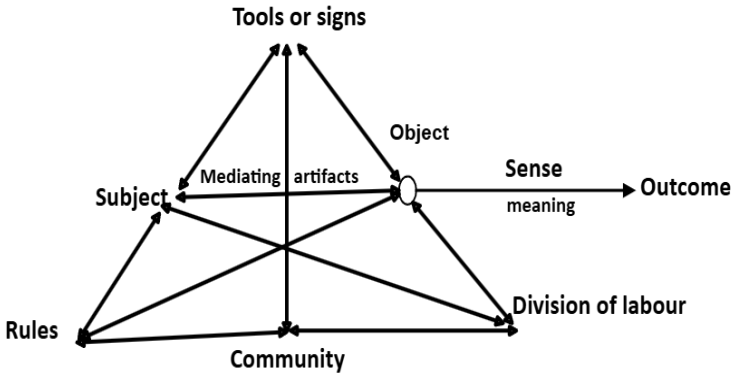

Figure 2 Second Generation activity system (Engeström, 2001b)

The third-generation CHAT was developed Engeström (2001) and includes the introduction of contradictions within and between interconnected activities. Here, the unit of analysis is the shared object (Engeström and Sannino, 2020). In the context of this study, agency is the recognition and negotiation of differences and complementarities. Researchers have recently developed a fourth generation of CHAT (Engeström & Sannino, 2020), which is different in that its unit of analysis is based on the coalescing cycles of expansive learning in a heterogeneous coalition of activities facing critical societal change. In this latest version of CHAT, Engeström and Sannino, (2020) argue that the object is a critical societal challenge or crisis demanding a multi-level and cross-sectional solution.

Second-generation CHAT was most appropriate for use in this study since it enables the conceptualisation of the use of digital technologies for learning as an activity system. In this framework, individual development

is understood as socially and historically constituted, occurring through participation in collective, goal-directed activities such as those found in engineering education (Rainio, 2010). Key components of the activity system, including the *community*, *division of labour*, and *rules* which encompass both formal policies and informal norms, shape how students engage with digital technologies and pursue learning outcomes (Engeström, 2001b). The identification of *contradictions* within the learning activity system is required for understanding both the challenges and opportunities for students to develop agency (Engeström, 1995). These contradictions, which may arise between institutional expectations and students' digital capabilities, can serve as catalysts for learning (Engeström, 1995). Furthermore, CHAT offers methodological tools for the identification and analysis of these contradictions (Engeström & Sannino, 2011).

3.1 Contradictions

Il'enkov (1977, 1982) introduced the concept of internal contradictions. These can be considered a driving force that causes constant change and development in activity systems (Engeström, 1999). According to (Engeström, 1987), these contradictions can arise within and between systems, and he distinguished four types: *primary*, which occurs within elements of an activity system; *secondary*, which occur between elements of an activity system; *tertiary*, which occur when the object of the central system clashes with that of a historically more advanced activity system; and *quaternary*, which occur between the central system and its neighbouring activity systems. The notion of contradictions have been widely used by researchers as a guiding principle of empirical research (Engeström, 1987, 2015) and have been applied to this study.

4 Methodology

This research explored student agency in a digital learning environment, employing ethnography as its core methodology due to its alignment with the interpretive paradigm (Hammersley & Atkinson, 2007, 2019). The interpretive paradigm, rooted in constructivism and relativism, acknowledges that reality is shaped through individual interpretations and social interactions (Denzin & Lincoln, 2011). Given its emphasis on understanding participants' lived experiences, ethnography enables the researcher to capture students' subjective meanings and interactions within the digital learning space (Hammersley, 2018). Through immersion in the natural setting, the use of this approach provides an improved perspective on the dynamic interplay between students, technology, and the broader social context.

The use of ethnographic methods also reveals tacit knowledge and implicit meanings that students might not have explicitly articulated, offering insights beyond what surveys or questionnaires can reveal (Alvesson & Sköldberg, 2017). However, despite its strengths, ethnography is time-intensive and carries a risk of subjectivity, requiring careful methodological considerations (Hammersley & Atkinson, 2007). To address these challenges, the research adhered to rigorous ethical guidelines, maintained reflexivity, and employed triangulation through multiple data collection methods to enhance credibility. By embedding researchers in students' daily academic lives, observing their actions, and conducting interviews, this study captured the nuanced manifestations of agency within the complexities of a digital learning environment.

4.1 Data collection

As the study employed an ethnographic approach for data collection, the use of observations, one-on-one and focus group interviews (Gobo & Marciniak, 2011; Hammersley & Atkinson, 2007, 2019) was appropriate.

Ten observation sessions were conducted, with five taking place in engineering drawing laboratories and five in computer engineering laboratories. To ensure comprehensive data capture, the sessions were both video recorded and documented in field notes. These field notes included detailed descriptions of observed activities along with the date of each session. Fifteen individual interviews and three focus groups were conducted face-to-face. This decision to prioritize face-to-face interaction was motivated by the ability to observe and capture participants' body language and non-verbal cues, which could offer valuable insights into their perspectives and experiences (Krueger & Casey, 2002). The data from individual interviews and focus groups were analysed and used in this paper.

4.2 Data analysis

Thematic analysis (Braun & Clarke, 2006) was the primary approach adopted for analysing the qualitative data collected. This widely used method involves identifying, analysing, and reporting recurring patterns called themes within the data (Creswell & Poth, 2018). Thematic analysis in this research involved a two-level coding process. The initial level made use of a combination of in vivo codes and descriptive codes (Saldaña, 2016). In vivo codes directly reflected participants' own words and phrases, capturing their unique perspectives and expressions without significant modification. Descriptive codes, on the other hand, summarized the underlying meaning of data segments using concise labels (Nowell et al., 2017; Saldaña, 2016). This initial coding served as the foundation for the second level, where themes were progressively identified by grouping and refining the initial codes based on their shared characteristics and relationships (Braun & Clarke, 2006).

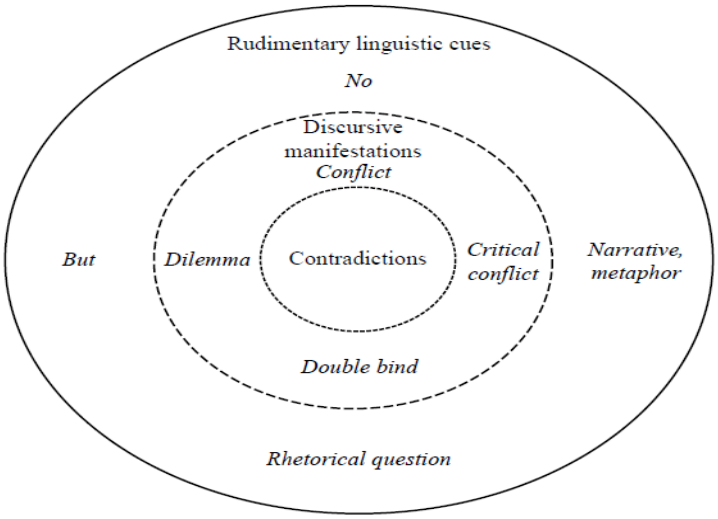

Figure 3 Methodological onion for analysing contradictions (Engeström & Sannino, 2011 p.375)

The identification of contradictions also started during the first level of open coding and involved iterative stages of thematic analysis to identify themes. Discursive manifestations of contradictions is a method within CHAT that identifies systemic tensions through the analysis of language, recognizing that contradictions are not immediately observable and cannot be discerned at face value (Engeström & Sannino, 2011). The linguistic cues for discursive manifestations of contradictions called *dilemmas* include "yes..but" which describes a form of doubt and/or hesitancy. *Conflict* is depicted by "no", "I disagree", whilst *critical conflicts* are characterized by "let us do that or we will make it". Lastly, *double binds* reflect situations where students

cannot help themselves and need others to assist them to get out of a difficult situation (Engeström & Sannino, 2011). Figure 3 shows the methodological onion for analysing contradictions as applied in this study.

5 Findings and discussion

The findings from the data analysis reveal that first-year engineering students encountered contradictions in the form of dilemmas, double binds, conflicts, and critical conflicts. Figure 4 shows various discursive manifestations of contradictions in the use of digital technology for learning.

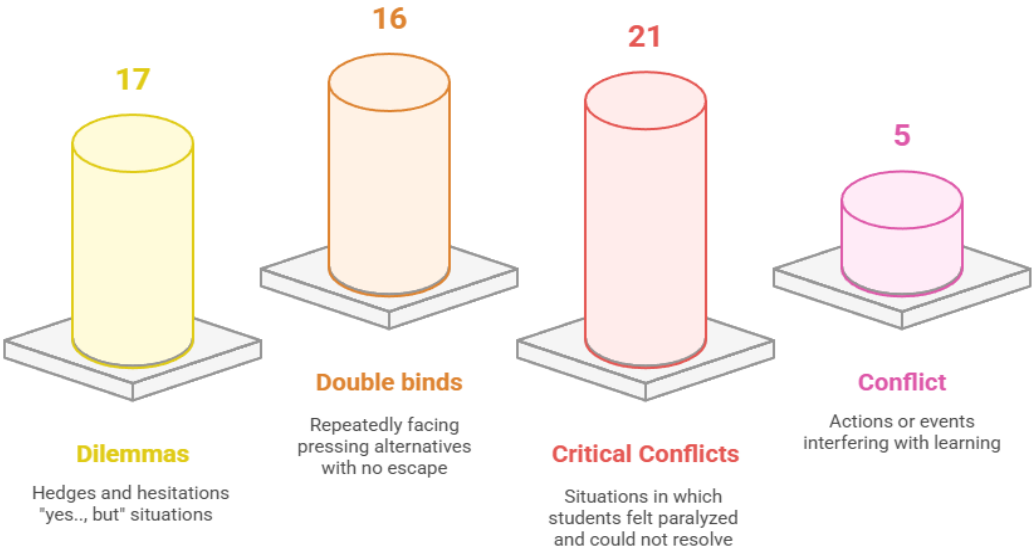

Figure 4 Discursive manifestations of contradictions among students

Four themes emerged from the seventeen dilemmas, whilst two and three themes were identified among the double binds and critical conflicts, respectively. There was also one theme that described the five conflicts that had been identified.

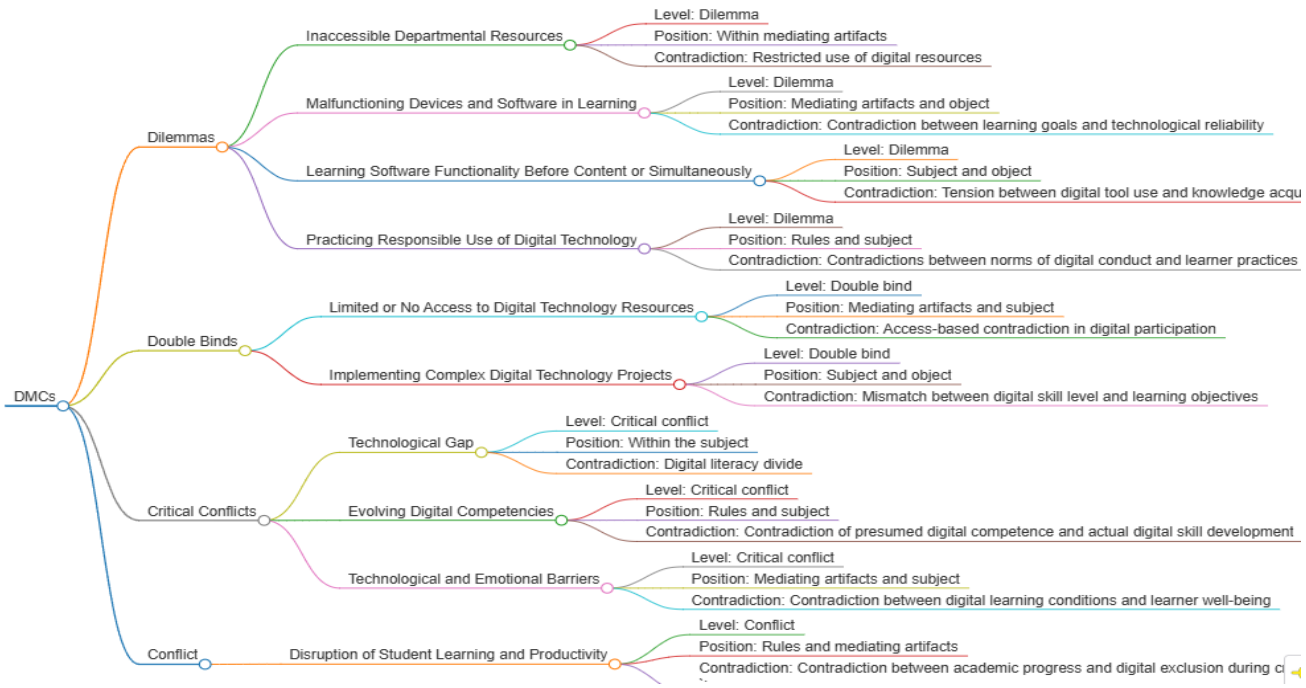

Figure 5 Categorised discursive manifestations of contradictions

The findings revealed that there were primary contradictions in the form of critical conflicts within the subject as an activity system tenet. The secondary contradictions were identified as dilemmas, double binds, conflict, and critical conflicts. Figure 5 shows the process of identifying contradictions from their discursive manifestations. Figure 6 shows the second-generation activity system in which first-year engineering students learn with digital technologies. The lightning bolts in the activity system indicate the positions of the primary and secondary contradictions.

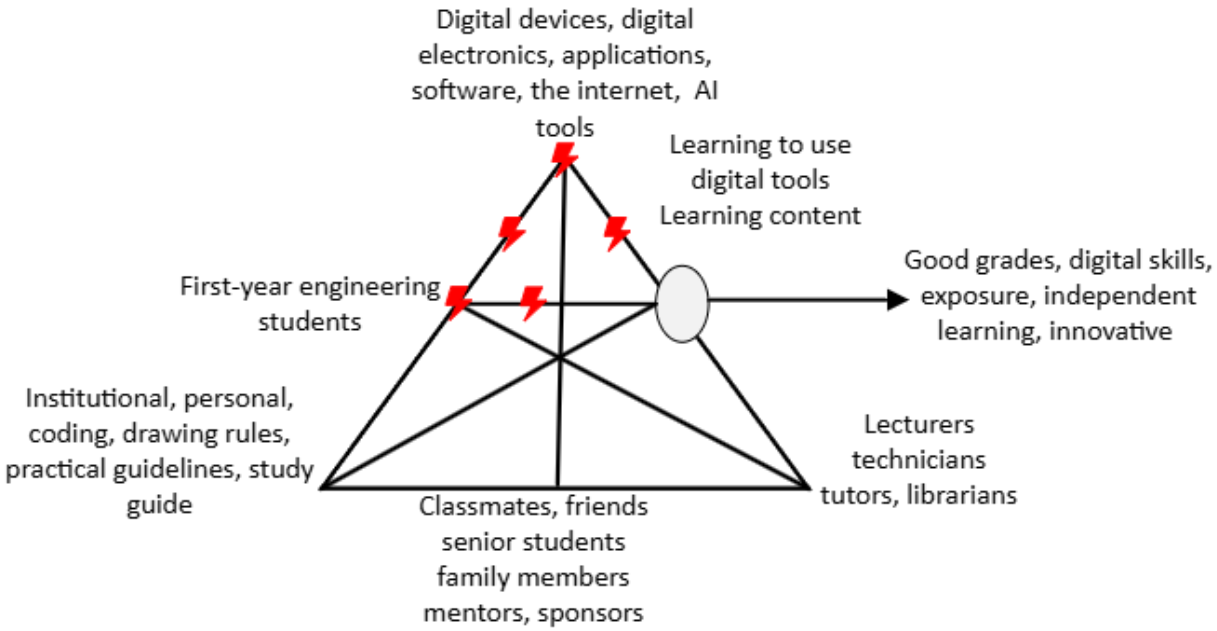

Figure 6 Students' learning activity system

The analysis showed various ways in which first-year engineering students exercised agency to overcome the contradictions. This paper focusses on three of the ways. Firstly, they exercised agency by investing time in constant practicing with software and hardware as a way to improve their digital skills. Secondly, they challenged the status quo and thirdly, they adapted to constraints to sustain learning throughout the year. These three ways that first-year engineering students exercised agency will be described in full in the sections to follow.

5.1 Practice as a key to understanding and applying digital tools

First-year engineering students were introduced to computer engineering and engineering drawing, subjects that required digital tools for their learning. The analysis indicated that students developed digital skills through constant practicing the application of digital technologies. They engaged in hands-on practice with the software, applying concepts that were either demonstrated through YouTube tutorials or documented through photographs taken during laboratory sessions. As an example, Spamandla commented: "*I'd go to YouTube, watch tutorials on YouTube, and then try to practice it on the software*" [FG3L411]. Protea believed that to understand technology, one must practice, and there is "nothing else". She stated: *"I think it was frequent practice on how to use it ...and also YouTube videos. It's frequent practice. Nothing else*" [I10L90]. Similarly, Beekay said: *"I actually try to practice more frequently so that I can actually get the glimpse of how*

to actually use the application that I have to actually use it into my advantage to get something out of it" [I4L142].

In addition, some engineering students were practicing on their own, whilst others collaborated with peers. They practiced how to use software such as Microsoft Office, AutoCAD, SolidWorks, MATLAB, Dev C++, and many others. Thumi is an example of a student who had to practice using Microsoft Word. She stated: "*I had to make sure that every day... I have to go into Word, do the exact thing again and again, take a break, and then go back in, try to figure out something else other than what I've learned*" [I15L90]. Swazi also attributed her success to practicing and gaining knowledge and familiarity with the tools. She asserted: *I remember the first few weeks I was just struggling with Blackboard, I didn't understand exactly how to use it and what it was for. But you know, the more you use it, the more you get used to it"* [I13L158]. Aphelele described that: "*me and my friends we meet up together maybe for computer engineering and try to practice codes and to write codes. So what we normally do, we send codes that we can practice to our WhatsApp group. And then we take it from there and then try to retype them to Dev C++ just for practice*" [I3L150].

Use of digital tools through repetitive practice was a primary pathway through which agency was developed and demonstrated. Agency among first-year engineering students manifested through their repeated engagement with digital tools as they sought to master both content and the technological instruments mediating that content. Rather than relying solely on formal instruction, students often turned to trial-and-error learning, self-paced experimentation, and peer collaboration to gain confidence with unfamiliar tools. Vygotsky's (1978) idea of mediated learning, where tools are internalised through use, explains this phenomenon. Luckin et al. (2011) extend this to technology use, showing that learners generate meaningful contexts for themselves when technologies are embedded in practice. This means that students' practice as a form of agentic learning is mediated by cultural tools. This notion aligns with Schubotz et al. (2023), who argue that tool mastering is not simply a matter of one-time use but a developmental process involving the integration of perceptual, motor, and cognitive competencies through repeated practice. In the context of digitally mediated learning, such repetition is not merely mechanical, it is an enactment of agency where students make intentional choices to build competence by actively shaping their interactions with technologies.

The engineering students' digital engagement, particularly through coding, Arduino circuits practicals, AutoCAD, and SolidWorks drawing, appeals to the three building blocks of tool mastering that Schubotz et al. (2023) describe as tool perception, selection, and handling. Ozturk et al. (2015) and Peng et al. (2014) also demonstrate that iterative modelling assignments allow students to customize their learning experiences, thereby improving both technical skills and epistemic engagement. Their recursive practice enabled the development of manipulation knowledge in how to use tools, functional knowledge concerning what tools are for, and means-end knowledge on how tools achieve specific learning goals.

Practicing engineering content as well as mastering digital tools unfolded within a community. Students shared resources, collaborated on Web 2.0 technologies, and consulted with one another. These social practices reinforced the affordances of tools and promoted a culture of peer-supported learning. As argued by Lund and Aagaard (2020), digital technologies only yield educational benefits when users actively

appropriate them in meaningful ways. Repetitive practice served as a mechanism of appropriation, transforming tools from obscure systems into familiar elements of students' cognitive repertoire.

5.2 Challenging and modifying the status quo

Engineering students consistently deviated from rigid curricular expectations and institutional constraints to explore ways of learning. This form of agency was marked by autonomous planning, critical evaluation of digital tools, and the willingness to cross temporal, institutional, and technological boundaries to access and engage with technology. One student, Khulekani, installed Linux instead of the recommended Windows operating system as he believed that it was faster in programming. He explained: "*So in computer engineering, ... I tend to go even beyond those rules to actually break those rules and write certain programs that don't make sense just to see how this program is going to react. And that's actually how I've enhanced my knowledge of how the language works, how the computer works, how the system reacts to such code*" [FG1L366]. Another student, Mbigu challenged the status quo by doing things outside his academics stating:

> "*So immediately when I saw that I was able to do the code, I gained confidence that I can even do it more. That's why I always even did practicals, like on my own practicals outside of academics, Google Arduino practicals that I can do with this and this and this component. Find them and then do it together. And the more I did that, the more I see coding, the more like I get interested in coding as well. Doing those tasks actually really boosted my confidence as well"* [FG3L580].

These actions represent a shift from compliance-based learning to actively reshaping the learning activity system, aligning closely with the concept of challenging and modifying the status quo within CHAT (Engeström, 2001a).

Another example where students challenged the status quo was during their first semester, where they were instructed to learn coding through ChatGPT. However, some students like Spamandla and Swazi did not rely on ChatGPT, while others checked the accuracy of ChatGPT using Google. Spamandla stated: "*I try to make myself less reliant on consulting ChatGPT for every hard code that we are tasked with"* [I12L380]. He proposed asking friends for help instead. Through innovation, critique, and boundary-pushing, students resisted being passive recipients of technology and instead asserted themselves as active agents in shaping how technology functions within their learning environments. Araos Moya and Damsa (2023), conceptualise such moves as critical engagement with the conditions of learning. Students questioned the fitness of existing digital structures and, in doing so, they enacted a reconfiguration of power and participation in learning spaces. These practices suggest that agency includes the capacity to critique, transform, and reimagine digital tools and practices, not merely to use or cope with them.

5.3 Adapting strategies to sustain learning

The third finding describes how students adapted to constraints through creative or improvised strategies. First-year engineering students encountered various obstacles during their studies but demonstrated agency by developing and applying strategies to overcome each one of them. For instance, instead of waiting for help, some students like Swazi, Mbigu, Kitso, and Aphelele would teach themselves how to code and do engineering drawings assignments. Other students like Spamandla and Khulekani tried to use ChatGPT correct their train of thought instead of directly writing their code. Spamandla explained: "*I always make sure that I first attempt the code, and then should I not be able to figure it out, I try to make ChatGPT correct my*

train of thought instead of it influencing my code" [FG3L50]. Engineering students in this study also found it easy to research solutions to their practical assignments, build a prototype, and test it to see if they got the required results. Aloha described how he would do "*a little research"* on what he was going to do, whereafter he tried to *"build it and then test it"* [I1L102]. Similarly, Beekay would use "*[Google] Chrome to get the information*" that he was looking for and "*analyze the data*" to "*select the most important information that he would need*" [I4L226].

In addition, agency was demonstrated through the use of online videos to learn to use software such as AutoCAD, a tool that is outside of the curriculum. Students such as Khulekani used software and applications that were outside the scope of the curriculum. Khukekani asserted: "*And for my personal experience, since I enjoy coding, I have a personal IDE that I love and I prefer, it's called Visual Studio Code. And I've been using it a lot*" [I6L30]. Similarly, to access resources like books and computers, engineering students would improvise by sourcing books beyond those recommended and also try to access computers at the library, IT centre, or borrow laptops from friends. During power outages, some students chose to submit their coding and drawing assignments ahead of the deadline. The adaptive strategies to sustain learning were a key expression of agency, especially under conditions of limited control. Czerniewicz and Brown (2014) show how students from disadvantaged backgrounds develop distinctive digital practices that reflect both constraint and initiative.

The adaptation of strategies to sustain learning is closely tied to the notion of boundary-crossing in digital engagement (Akkerman & Bakker, 2011). Possible boundary crossing was evident as students accessed and used digital technology for learning. The strategies demonstrate that boundary crossing is not merely about interaction across domains but is central to collective concept formation, an essential mechanism of learning in CHAT. As Suchman (1994) also notes, boundary crossing entails entering unfamiliar terrains and negotiating partial knowledges, making it a cognitively and relationally demanding process. In this study, this principle is crucial because it emphasizes how learning moved across curriculum boundaries and transformed the activity system, fostering horizontal development through collaboration, contradiction, and mediation.

Furthermore, whilst institutional systems were insufficient, students demonstrated agency by creating or identifying parallel networks of support, including friends, classmates, and senior students. For instance, Aloha commented: *"They are my friends. One of my friends is good with computers because in our friend group, one knows this thing, one knows this module. So one of my friends helped me to use Dev C++"* [I1L143]. Khulekani supported this by saying: *"Fellow classmates … contribute in helping you because we don't learn in the same way. We grasp things in different ways"* [FG1261]. This is consistent with Zhang et al. (2017), who also noted that when students are tasked with creating screencasts, their study found that students must first overcome initial discomfort and gaps in technical knowledge. The screencast process itself became a coping mechanism where students engaged deeply with the material to explain it to others, which requires internalising and structuring the knowledge meaningfully. Thus, the creation of learning artefacts becomes both a form of mastery and a strategy for managing initial uncertainty or lack of confidence. Johnson et al. (2014) showed that contextual exercises that accommodate varied student experience, for example, in CAD environments, encourage engagement by recognising that students use new technologies differently depending on their background and prior exposure. This conclusion is consistent with Engeström's (2001)

model, which puts emphasis on the role of community in influencing subjects such as engineering students to achieve their objectives.

6 Conclusion

First-year engineering students enter university from diverse socio-economic backgrounds that significantly influence their prior access to digital resources and, consequently, their development of digital skills. This study examined how a sample of these students engaged with digital technologies, using discursive manifestations of contradictions to identify areas of systemic tensions within the activity system. Despite facing structural disadvantages, students demonstrated agency by actively navigating and overcoming these contradictions. They did so through sustained engagement with digital tools, creative problem-solving, and by challenging and reshaping normative expectations within their learning environments.

These findings provide insights for engineering educators, showing that digital technologies can act as barriers to equitable student learning. Recognizing these challenges enables educators to design pedagogical interventions that support students in developing digital skills and competencies before engaging with complex engineering concepts. By addressing these barriers, educators can create more inclusive and effective learning environments for engineering students.

For engineering education researchers, this study highlights that exploring student agency in digitally mediated learning environments remains a productive area for research, given the pace of innovation in digital technology. As digital tools continue to shape learning experiences, further investigation is needed to understand how different technologies facilitate or hinder student agency. This research contributes to the growing body of engineering education knowledge and encourages continued exploration of student agency within diverse technological learning environments as an important area for future study. The research's limitation encompasses the reliance on a singular method for identifying contradictions within CHAT to study agency. The researcher advocates for the inclusion of Change Laboratory and other CHAT-based methodologies in future studies to facilitate a more thorough examination of agency.

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