Exploring Student Usage of ICT Tools in Project-based Learning

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***Abstract*— Interactions with ICT tools may affect students' mental (cognitive), behavioural, and emotional experiences differently. This paper examines the relationship between the emotional experiences of students in a postgraduate ICT course at a major Australian university, technology used in the course, and their academic performance. The research question is: Which attributes (cognitive, emotional, or behavioural) does a learner exhibit when interacting with online ICT education tools? A survey consisting of closed-ended and open-ended questions was used to understand the effect of prior experience on learner engagement. Our findings indicate that: 1) the behavioural element was most affected by ICT usage, 2) there was more engagement between students and teachers than between students and other students, and 3) students were more productive if they had previous experience with online tools. Based on these results, we argue that design specification requirements should focus on ensuring that students have familiarity and background with online learning, to enhance their help-seeking, information literacy and communication.**

***Index Terms*— ICT Tools, Cognitive, Emotional, Behavioural, Educational Technology**

I. INTRODUCTION

Previous research on learning technology indicates that an intentional curriculum design focusing on the interplay between technology and learning can lead to educational improvements in students (Vasimalairaja et al., 2020). Building expertise in technology also contributes to enhancing professional conduct in education for both students and teachers (Garrett et al., 2018). McTighe et al. (2020) note that technology-enhanced learning tools in the classroom should suit specific purposes of the course; however, there is still a lack of theoretical guidance on how course designers can implement this consistently (Bartolomé et al., 2018). Since the education spectrum is vast and complex, developing theoretical frameworks is challenging (Dao et al., 2019). In particular, the increasing demand for online learning and delivery modes mean that ICT tools need to be considered more carefully for a comprehensive educational experience.

This study investigates the impact of educational ICT tools on learner engagement, in the context of a postgraduate ICT course at a major university in Australia, delivered online. This course focused on Project-based Learning (PBL), with students completing individual projects. Due to the range of projects, the scope of this research is solely on the communication and interaction tools used by students to complete their assessments. We developed a survey instrument based on three dimensions of student engagement (Fredricks et al., 2004): cognitive, behavioural, or emotional. These dimensions are used to explore how students are most affected when using or interacting with educational ICT tools in the online setting.

This research seeks to answer the following research question: *Which attribute (cognitive, emotional, or behavioural) does a learner present when interacting with online ICT education tools?*

II. BACKGROUND

Educational technology has a substantial effect on students' cognitive, behavioural, and emotional development. Due to this development, many educational institutions use technology to elevate modern-day academic teaching (Karaka-Clarke, 2020; Singh & Tiwari, 2020). ICT may provide learners with engaging and efficient information when used in conjunction with traditional educational systems. In particular, they can contribute towards personalised education experiences, which positively affects the learning process (Vasimalairaja et al., 2020), and might lead to elevated intellectual skills.

Elevated intellectual skills include self-reliance, creativity, communication, cooperation and digital attainment. According to Calder and Murphy (2018), technologically supported learning environments that embrace self-regulated education alongside knowledge-based learning can help students be more contemplative, creative, and innovative. They posit that, in turn, this has the capacity to lead to enhanced aspects of learning, such as self-directed education, cooperative learning, independent study, and simple response and feedback. Students that can be encouraged to develop or experience these skills in their educational setting can be more prepared and resilient for professional careers post-university.

Adopting intentional educational technology in the learning process also fosters creative thinking and ensures that learners

are equipped with relevant resources to aid them in their learning process. Creative thinking can be made explicit in several learning contexts. Gardner (1983; 1999), for example, saw creative thinking as a cognitive process in which several intelligences worked in harmony and could be used anywhere, with thinking and innovating two common outcomes. But the notion of creative thinking is complex and an area of learning in need of more investigation. Teachers need to justify their use of ICT and explain the effectiveness of computer-supported learning in the form of measurable student attainment.

Evidence shows that adopting ICT tools improves students' learning (Vasimalairaja et al., 2020). Students who have incremental experience with ICT tools are better positioned to learn than those who have no access to the same tools. Customised tools such as instant feedback functionality enhance real-time interactions and assist learners in meeting specific educational goals (McTighe et al., 2020). However, for this to be effective, incorporation of ICT tools into the learning process requires a rational approach (Lieder & Griffiths, 2020). A customised learning experience contributes to student's connection and experience, which affects their prosocial conduct as the quality of societal interaction is linked to learners' overall knowledge (Wittek et al., 2020). This experience, in turn, affects the user in the cognitive, emotional, and behavioural dimensions. Each of these are important concepts in student engagement research.

Cognitive engagement as a concept draws from different research streams, with the first seeing it as a person's psychological investment in learning and the other considering it strategic learning (Fredricks et al., 2004). Emotional engagement refers to the affective reactions in an educational setting such as interest, enjoyment, or sense of belonging, while behavioral engagement is the extent to which students comply with behavioural norms such as attendance and involvement or showing positive conduct (Trowler, 2010). While these concepts of engagement are entirely individual and thus difficult to predict, technology can be used to facilitate positive emotional and psychological involvement in scholarly activities (Bond et al., 2020).

A systematic review by Loderer et al. (2020) that surveyed a total of 186 studies concluded that emotions are key drivers of learning in technology-based settings, with the characteristics of these settings having a significant capacity to shape learners' emotional experiences. In an empirical study focusing on cognitive engagement in particular, Iqbal et al. (2022) found that emotional intelligence (self-awareness, self-motivation, regulation of emotion, social skills) were critical predictors in the development of cognitive engagement in higher education students. There is a need to understand further how particular ICT tools can affect learner engagement.

When using an online ICT tool, the interaction may have an impact on users' mental wellbeing (cognitive), observable actions and reactions (behavioural), and feelings (emotional). However, to develop effective educational ICT tools and utilise them within a particular curriculum, it is essential to determine which learning attributes (cognitive, behavioural, or emotional) the ICT tools affect most. This knowledge will enable course developers to design efficient and personalised ICT education tools that optimize student engagement.

III. Methodology

We adopted a survey design using a mixed-methods approach, consisting of qualitative and quantitative questions. By breaking down the problems into subgroups that correspond to emotional engagement and prior experiences, the researchers determined the relationship between the user attributes and the overall user experience. The qualitative approach was utilised to answer why and how specific events occurred, incorporating quantitative questions. This dual approach aimed to understand the connection between individuals' emotional, behavioural, and cognitive experiences and their use of technology in learning in a postgraduate ICT course at a major university.

A. Participants

Our study setting was a PBL postgraduate course in the IT program at a major Australian university. The cohort contained domestic and international students, which is an appropriate selection for technology-based research (Chen & Yang, 2019). The participants were pursuing different Majors, which provided this research with a broad scope. For assessment, students were enrolled in shared research topics that were supervised by a member of the teaching team. While students may have used the same datasets, each student was required to develop a unique research question to ensure assignments were conducted individually. The critical learning outcomes (CLOs) in the course were information literacy, research skills, and academic writing. Course content was delivered through lectures and tutorials, while students were expected to access the library and academic advisors for additional research support.

Communication in the subject was largely digital, with project teams using online platforms such as Slack or university forums throughout the semester. In addition, as part of assessment (and depending on datasets), students needed to utilize individual tools and technologies to complete their research. Students were expected to be self-directed and demonstrate self-efficacy in accessing resources such as the external co-curricular support services. As part of the research scope, we only consider communication tools for cognitive, emotional and behavioral engagement.

B. Data Collection

A survey was administered to the entire course cohort in the middle of semester 2. Out of 267 students, 43 completed and returned the surveys. The survey was approved by the university's human research ethics committee. This study used convenience sampling, given that the researchers were involved

in the course.

Personal data was collected from the participants, including gender, age, nationality, domestic or international student status, language, and course. Data related to students' engagement with ICT tools, previous experiences, and attitudes were also collected. The survey contained open-ended and closed-ended questions. The researchers developed the quantitative questions based on a five-point, Likert-type (1–5) scale. Table 1 shows the closed-ended survey questions, which were designed to understand the interplay between students and technology in the course. These questions were shaped by a *focus*, or the underlying nature of the question. In addition, we used three open-ended questions to understand the learners' experience while using the ICT tools. The questions are shown in Table 2. These questions were multiple choice, offering different options, with students then asked to elaborate qualitatively about why it was their preferred approach. Students could not skip these questions without providing a qualitative response, resulting in rich responses for analysis.

TABLE I: CLOSED-ENDED SURVEY QUESTIONS, THEIR FOCUS, ESSENTIAL ELEMENTS, AND THEMES.

Question	Focus
"My experience with technology reduces the effort I need to get better grades in this unit's tasks."	Determine whether a student's prior experience with technology has an impact on their current performance.
"Students should receive training on using the virtual learning environment and ICT tools when they enroll in a unit task."	Determine the student's general viewpoint on the impact of training on fundamental understanding and experience when using ICT tools in learning.

TABLE II: OPEN-ENDED SURVEY QUESTIONS, THEIR FOCUS, ESSENTIAL ELEMENTS, AND THEMES.

Question	Focus	Key attributes	Discovered traits
"How are you interacting with other learners or staff while participating in this project?"	Determine the student's interaction levels with colleagues and tutors.	Endeavour, focus, requesting help, supporting others, optimism	Student engagement, cooperation
"Have you ever finished an online course in the past? If yes, what attracted you the most?"	Determine whether the student has had prior experience with online studying, and, if so, what they liked about it.	Endeavour, focus, punctuality, trying	Online experience, cooperation, and student engagement
"While attending to your assignments in a unit, how do you plan your advancement?"	Determine whether the student does assignments out of free will or feels forced by the course requirements.	Student activity state, punctuality, endeavor, focus optimism, trying, and self-assurance	Course requirement, student engagement

These sets of questions analyze students' emotional, cognitive, and behavioral experiences when engaging with communication technology tools for learning. The am is to understand how and why students have these experiences during their engagement with ICT tools. The quantitative and qualitative approaches ensure that both the quality and quantity of the data are incorporated into the research and support and enhance the findings' credibility (Sechelski & Onwuegbuzie, 2019).

C. *Data Analysis*

The researchers analyzed to what extent these relationships impacted the user attributes (emotional, cognitive, or emotional) and overall learning experience (Apuke, 2017). Statistical Package for Social Sciences (SPSS) version 22 (IBM Corporation) and ANOVA software were used to analyze the quantitative results for the closed-ended questions. To analyze the qualitative data, we followed an exploratory approach derived from the open-ended questions similar to Kaur et al. (2018). Narrative analysis was used to generate themes from the responses (Kiger & Varpio, 2020). The researchers analyzed each response individually to determine patterns, then developed codes from the responses corresponding to the patterns to serve as keywords. Keywords were then categorized into themes, and each pattern was grouped into categories to determine the themes (Vanaken & Hermans, 2021). The next step involved merging or deleting the compositions according to relevancy. This ensured that only relevant data was retained for further analysis.

IV. Quantitative Results

A. *Demographic Information*

Of the 43 responses, 30 were male and 13 were female. Participants came from diverse age groups, as indicated in Figure 1.

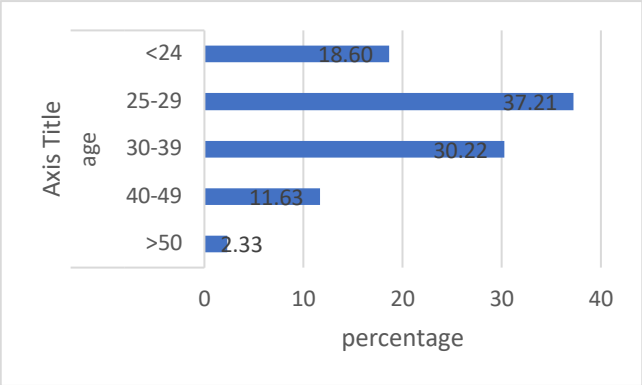

Fig. 1: Age range of the participants.

A total of 65% were international students and 35% were domestic. Figure 2 shows the breakdown of majors in the course, with computer science being the most strongly represented.

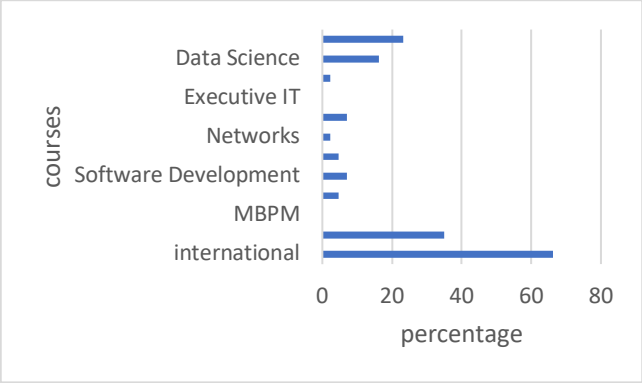

Fig. 2: Current majors of the study population in the course.

B. Behavioural Attributes and Technology Use

In Figure 3, we can observe that ten participants (23.6%) strongly agreed and seventeen participants (39.53%) agreed that their previous experience with technology made it easier for them to attain higher grades. Figure 4 demonstrates that most respondents believe that students should receive training in the ICT tools of a course at the beginning of the semester, with 14 (32.56%) strongly agreeing and 19 (44.19%) agreeing.

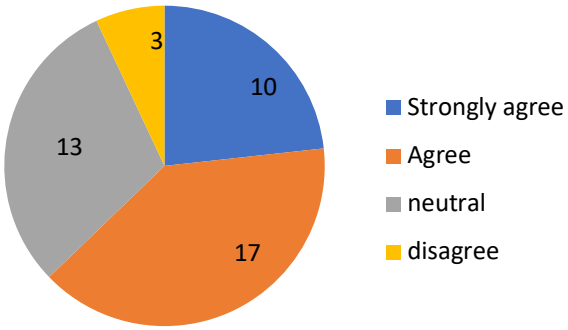

Fig. 3: "My experience with technology reduces the effort I need to get better grades in this unit's tasks."

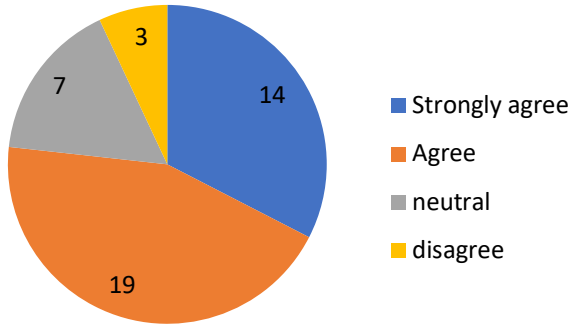

Fig. 4: "Students should receive training on using the virtual learning environment and ICT tools when they enroll in a unit task."

These results show that students believed their experience with technology significantly impacts their attainment of higher grades. Furthermore, the students believed they should receive training on how to use technology tools upon enrolling in the course. This aligns with previous studies, which note that training makes it easier for students to fully utilise available resources (Lawrence & Tar, 2018). Training also improves students' ICT literacy and forms a basis for the students to explore creativity and nature, which are both key behavioural aspects. Being ICT literate also improves students' attainment levels.

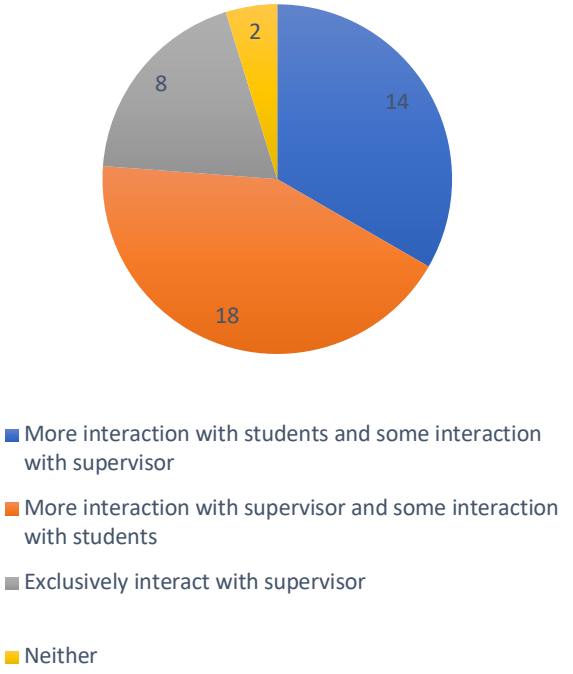

Fig. 5: "How are you interacting with other learners or staff while participating in this project?"

Figure 5 shows that the majority of participants had a mixed interaction within the course, with 18 (41.86%) specifying that they interacted more with their supervisor, while 14 (34.88%) indicated that they interacted more with other students. The importance of this result is that it showed most of the students were actively engaging in communication with others. Students were not mandated to engage with peers or staff as the course was largely self-directed and had limited group activities, however, the students still desired interaction and were actively doing so through Slack and email. Interaction fosters active learning by keeping students engaged with others sharing a common goal; through the exchange, idea sharing, and shared goals, students can achieve more as a team than they can as individuals (Lamb et al., 2018). However, students may perceive that interaction with the supervisor is more helpful than interactions with fellow students.

Figure 6 shows the results for the students' previous experiences with online courses.

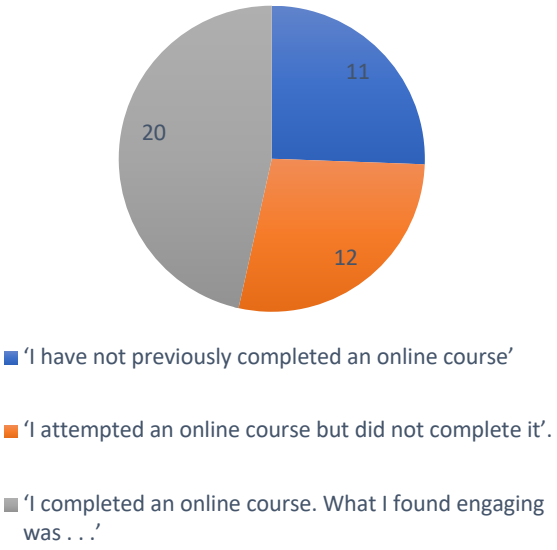

Fig. 6: "Have you ever finished an online course in the past? If yes, what attracted you the most?"

Of the total sample, 31% responded that they had never previously finished an online course. Another 31.88% had attempted an online course but not completed it, and 48.86% had completed an online course at least once. This question explored previous experience with online learning. Its relevance to this study is that most of the peer and supervisor interaction was through online platforms or email. Therefore, a learner who has previously taken an online course using ICT tools may be better positioned to approaching PBL using this online learning system compared to a student who has never taken an online course before. Even if the infrastructure is different, experienced students may have basic fundamentals. Familiarity makes it easier for a user to quickly identify and understand learning features and maximise the tools necessary for the online learning experience. Experience also gives them confidence and self-assurance that they are well equipped to handle the tasks beforehand (Didee, 2020). Figure 7 shows the results of the final question in Table 2, in which we ask the students for their learning style, or more specifically, their approach to completing assessment tasks.

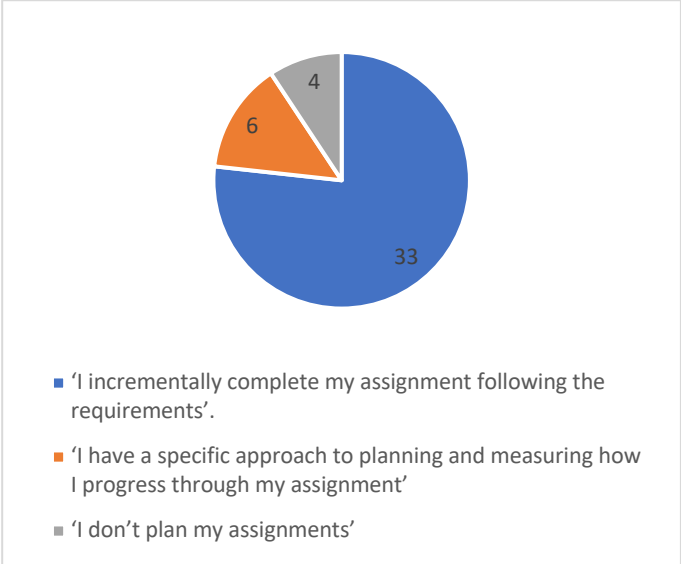

Fig. 7: "While attending to your assignments in a unit, how do you plan your advancement?"

The data shows that most (76%) incrementally completed their assignments following the requirements, which means that their motivation to complete their tasks was dictated by academic requirements. This factor measures whether a student feels either self-driven or forced by the course requirements. Online courses require consistent effort to complete assignments and self-driven traits are key to cognitive, emotional, and behavioral engagement. Some students may complete their assignments out of passion, while others meet their deadlines because their course requires it for attainment of their academic qualifications. In this study, the students were optimistic and focused on achieving their educational goals through positive behavior.

C. Qualitative Analysis: Trait Development

The open-ended questions in Table 2 asked respondents to explain why they selected the MCQ answer. These qualitative responses were analyzed using the process described in Section III C. One researcher coded the qualitative data into codes, and the researchers then grouped codes into high-level themes. These were derived from the language of participants, either from verbatim words given in the response or a theme being a word that encapsulated similar meaning from multiple respondents. In Table III, the themes are distributed across two categories: *key attributes* about individual student emotions, and *discovered traits* being high-level, program-oriented traits.

TABLE III: OPEN-ENDED SURVEY QUESTIONS CATEGORIES.

Question	Key attributes	Discovered traits
"How are you interacting with other learners or staff while participating in this project?"	Endeavor, requesting help, supporting others	Student engagement, Cooperation
"Have you ever finished an online course in the past? If yes, what attracted you the most?"	Studentship, optimism, self-assurance, focus, trying	Online experience
"While attending to your assignments in a unit, how do you plan your advancement?"	Studentship, punctuality, endeavor, focus optimism, trying, self-assurance	Course requirements

The themes in the key attributes column broach across each of the engagement concepts. For example, 'studentship' was a type of cognitive engagement alluded to by several students as underlying a desired state that drove them to invest in their learning. Emotional engagement was shown in attributes like 'optimism' and behavioral engagement was shown in attributes such as 'punctuality' and 'trying'. Table 3 indicates that these attributes were observed across each of the questions, highlighting their importance. The themes in the discovered traits column are high level in that they encompass most of the engagement concepts. For example, 'cooperation' was indicated by students as being a driver for their communication with tutors and peers, and as a concept, 'cooperation' can be considered each of cognitive, emotional, and behavioral engagement.

To answer the research question for the study, our findings indicate that all engagement attributes are present among students in a PBL course, however, cognitive engagement showed the most in themes such as 'endeavor', 'supporting others', 'studentship' and 'cooperation'. More importantly, prior experience with technology and the online course environment better prepare students for the demands of PBL, in particular developing skills like help-seeking, information literacy and communication. If students do not have this familiarity and background, then courses need to train students with the technology and how to use them for these attributes upon enrolment in the course.

V. FINDINGS

The data showed a positive relationship between learners' previous experience and their study unit performance. Experience also contributed to learners' interactions with the ICT tools: the more exposure students have had, the more accustomed they become (Kompen et al., 2019). The learners develop confidence in what they are doing. Elements such as previous online experience, communication, and student proactiveness with assessment also boost and contribute to the behavioural element (Pietarinen et al., 2019).

Student engagement contributes positively to performance, consistent with Bond and Bedenlier (2019), who noted that more engagement translated to better understanding. More engaged students perceived themselves as performing better than disengaged students. Thematic qualitative analysis depicted that the course requirements pushed them to complete their assignments, and most of the students engaged more with their supervisors than with their colleagues. This shows that the cognitive dimension of engagement gets more credit than the other elements with regard to the connection between students' performance and their interaction with ICT tools.

The results showed that most students engaged more with their supervisors than their fellow students, translating to their engagement mode. The students believed that to gain help, their supervisor was better positioned to offer assistance than their fellow students, another cognitive trait. This confirms earlier studies that found students tended to be more motivated if they could communicate with and get help from their teachers (Ozkara & Cakir, 2018). According to a study by Pınar and Dönel (2020), learners prefer classical courses, finding them more motivating, intelligible, and understandable when they got assistance from their teachers. In this and previous studies, teachers agreed with students that active interaction was very important, and students were optimistic that their performance would increase if they had experience with educational ICT tools.

A. Study Limitations

Our small sample size has a negative impact on the generalizability of the findings; the data collection methods are reflective of the time and geographic restrictions of the investigators. Nevertheless, participants' responses helped the investigators better understand learners' perspectives.

B. Recommendations

1) A PBL course should foster and encourage more interactions between students, even if the assessment is individual. Most respondents described more interaction with their supervisors than with their fellow students. Although the majority of students believe that most information comes from supervisors, fellow students can also provide ideas. Interaction with fellow students can foster idea sharing and overall growth and achievement.

2) Accessibility to learning resources should be improved,

such as having an online assignment protocol to improve students' assignment uptake. Most respondents stated that the course requirements compelled them to complete their assignments. More compelling yet accessible online assignment access and submissions to boost students' assignment uptake would be helpful.

3) The course should offer training for learners to explore ICT educational tools. Some students were not familiar with the setup because many had not experienced an online course before, so they were not familiar with expectations involved in using Slack, university forums, Zoom, and recorded lectures. As Ballesta and Céspedes (2015) argued, being suitably trained in the use and educational possibilities of ICT is one of the major factors in inclusivity. Instructors need to ensure all students have access to learning, geared towards assisting students to improve their key qualifications (Valdés et al., 2015).

VI. Conclusion

This study was motivated to explore what dimensions of student engagement among cognitive, emotional, and behavioral engagement were present in an online PBL course. It found that cognitive engagement was most present, especially in the use of ICT tools for communication. This study found that most students relied on experience to utilise ICT tools effectively for student engagement and learning. The online ICT learning tools elevate interactive and overall delivery in the education system (Fisk et al., 2020). Our findings suggest that most students spend more time engaging with their supervisors than their fellow students. This indicates the cognitive engagement dimension of learning (Hong et al., 2017), in that it is an investment of learning and strategic. Future improvements made to the ICT tools should foster inter-student engagement and interaction. This modification can be achieved by simplifying design to make tools easier to use, especially for students with no prior experience using online ICT educational tools (Yang et al., 2018).

Recommendations to improve the efficiency and tool reliability in ICT systems will also contribute to overall academic development (Tarus et al., 2018). These findings depict the general trend in educational ICT technology globally, contributing new information to the knowledge pool in this field. The findings can be applied in many educational scenarios as a basis for problem resolution.

This research has some limitations. Due to the small sample size, these findings cannot be generalised. This study also involves only two variables: learner engagement and learners' experience. Many factors contribute to the application of ICT tools in learning other than the two variables in this study. Therefore, there is a need for further research in this area. Further research can incorporate a larger sample group that is also geographically expansive and include more variables to understand the relationships in educational ICT tools, focusing not only on the effect of the design but also on the systems' effectiveness.

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