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Technology-enabled Active Learning (TEAL) – A Study of its Influence on Student Learning

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Full Research paper

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Abstract

Using an active learning framework proposed by Shroff et al (2019), our study evaluates the impact of technology-enabled active learning (TEAL) on student learning in an Australian business school, using the individual reflections of accounting students as data collection strategy. We found positive influence of the three constructs of the framework - interactive engagement, problem solving and feedback on learning. Our study found interactive engagement, development of problem-solving skills and individualized learning context enabled by accounting technology have positively contributed to the learning effectiveness. Technology-enhanced scaffolds designed in the learning process have contributed to the consolidation of learning and to learning effectiveness. Our study observed that though students' interest and curiosity enabled by technology is expected to have positive influence on learning, lack of student effort, poor timing of feedback, and absence of a sense of challenge, have limited their learning.

Keywords

Technology-enabled Active Learning (TEAL), engagement, feedback, curiosity, learning, accounting.

1 Introduction

The adoption of educational innovations that incorporate active and blended learning strategies and introduce students to various industry standard tools are considered useful by higher educational institutions to improve learning (Pierce and Fox 2012; Blount et al. 2016; Apostoulou et al 2022). Active learning approaches stimulate higher thinking processes (Kim et al. 2013), develop critical thinking and problem-solving skills (Mumtaz and Latif 2007), and foster students' ability to create new knowledge and apply acquired knowledge and skills (Ni Raghallaigh and Cunniffe 2013). Technology is often used in such active learning environments to support learning processes and activities that include immersion, exploration, and reflection (Noteborn et al. 2014) and engages students in the learning of management accounting by facilitating meaningful learning activities (Matherly and Burney 2013). Embedding information technologies into business curriculum through active learning not only gives students an opportunity to take control of their learning (Marton 2018), but also helps them become 'work ready' (Davern et al. 2019; Daff 2021). Though accountants are required to have knowledge and skills to interact with and interrogate modern accounting systems and technologies to support managerial decision making, courses offered by Australian universities, are limited in their ability to prepare students for the 'real world work' (Rowbotham 2020; Betti et al 2022).

To deliver active learning pedagogy, business schools adopt information technology tools as enablers. While some initiatives deploy technologies to help the learning process, others use business applications such as Enterprise Resource Planning (ERP) systems for teaching business concepts such as accounting, business processes and integration in business schools. Though there is no consensus on the topics and the extent ERP systems are contextualized in teaching accounting (Badua et al., 2011; Wijaya 2023), several courses predominantly use ERP systems for teaching financial and management accounting concepts and related processes (Neely et al., 2015; Wijaya 2023). This study, uses SAP, an Enterprise Resource Planning (ERP) system as the mediating technology and a technology-enabled active learning (TEAL) framework proposed by Shroff et al (2019) as a theoretical anchor, to evaluate its impact on students' learning. Using individual reflections of management accounting students in an Australian university business school as data collection strategy, our study examined how the four constructs of the TEAL framework - interactive engagement, problem solving, interest and feedback, influence student-learning.

Our study found that interactive engagement, problem-solving skills, and interest enabled by the technology, have positively contributed to students' learning. Inadequate student interest characterized by low levels of engagement, unwillingness, poor exertion of time and efforts, and inadequate feedback offered by the faculty and technology are found to be challenges that inhibit learning. Timely inputs and ongoing feedback while students are interrogating the technology during and after workshop activities and on the progression achieved, and remedial steps while analyzing the case study, are found to be important for demonstrable improvement in learning and knowledge acquisition.

Our study offers empirical evidence to the effectiveness and value of technology-enabled active learning in accounting education. Our findings have the potential to influence the way technology-enabled active learning is incorporated into the curriculum without overly emphasizing technology at the cost of basic discipline related concepts and by addressing the individualised needs of students. Thus, as advocated by Neely et al (2015), this study educates students on what SAP ERP software could do in supporting various management accounting processes rather than the software itself. Moreover, the study shows how the use of technology in classroom facilitates alignment with what students are likely to experience in the profession (Boulianne 2014; Borte et al 2023). Next section briefly reviews the literature, followed by a discussion of the theoretical anchor and methodology, and ends with findings and conclusions.

2 Literature Review

Various scholars define active learning differently, and there is no consensus on its definition within the research context. Van Hout-Wolters et al (2000) define active learning as "*the extent to which the learner is challenged to use his or her mental abilities while learning*" (pp.1). According to Hung et al (2006), active learning is the process of learning in which learners are accountable for their own learning. Active learning refers to instructional approaches that enable active student engagement through collaboration. Bonwell and Eison (1991:2), in their seminal work, define active learning as 'anything that involves students in doing things and thinking about the things they are doing'. Active learning helps students to create new knowledge, apply acquired knowledge and skills, demonstrate judgement and responsibility (Ni Raghallaigh and Cunniffe 2013). It is expected to improve students' retention of knowledge, critical thinking, and problem-solving skills (Mumtaz and Latif 2007) and is considered more effective than traditional teaching (Chiu and Cheng 2017). By using a combination of modified lectures, hands-on workshops, clear guidance/instructions and timely feedback, active learning environment is expected to encourage students to take ownership of their learning (Marton, 2018), inspire higher level of engagement (Su and Cheng 2015) and reinforce higher order thinking processes (Kim et al 2013). Active learning activities involve collaboration, problem solving, interactive engagement and reflection and requires participation in cognitively challenging problem based tasks that capture students' interest (Chin and Wang 2021). Activities such as working with peers, solving case studies, doing tasks, carrying out brief exercises, engaging in cooperative learning, interactively engaging with the learning environment are examples of active learning strategies (Cooper et al. 2018). Technology plays a key role in the implementation of such active learning strategies.

In fact, integrating technology into the learning environment is considered a key element of active learning (Hasan et al. 2015; Shroff et al 2023). Integrating technology-enabled tools into the learning environment to perform active learning strategies could potentially change how problem based and collaborative learning strategies are used in teaching and learning activities (Bedenelier et al. 2020; Shi et al. 2021). Effective integration of technology enables learners to not only reflect on their learning processes and outcomes, but also helps them subsequently develop critical thinking and problem solving skills through constructive feedback (Shroff et al. 2023). By facilitating efficient interaction and active problem-based learning methods, it supports students' intellectual capabilities and deep-learning based approaches to learning (Sugent and Suryani, 2020).

Technology, though, is expected to support active learning and the co-construction of knowledge, it is mainly used as a tool to administer content (Borte et al 2023) in many learning environments. For example, technology is used in massive online open courses (MOOCs), to distribute learning materials through learning management systems, to facilitate online collaboration by providing discussion forums and through google documents for sharing work and documents. This administrative use of technology does not exploit the interactive potential of the business technologies that are contextualised to the learning content and discipline knowledge and does not facilitate interactive engagement, interest, problem-solving and feedback, key elements of active learning.

In response to calls for curriculum renewal by professional accounting bodies and practice to conform with workplace requirements (Mantai and Calma 2022), accounting education has been changing and attempting to integrate technology into learning (Pierce and Fox 2012; Boulianne 2014; Apostolou et al 2022). Various accounting technology tools such as MYOB, QuickBooks, SAP and Power BI are deployed into accounting curriculum (Seethamraju 2010; Neely et al. 2015; Behunova et al 2019; Apostolou et al 2022). Deploying such contemporary and emerging technology tools used by the industry, not only facilitates learning through interactions of learners with peers, instructors and learning materials (Alavi and Leidner 2001), but also help them become 'work ready' (Blount et al. 2016; Daff 2021).

attempts to integrate enterprise system technology tools, such as SAP, into curriculum have their benefits and challenges (Alshare et al 2015, Behunova et al 2019, Wijaya 2023). While Laosethakul et al. (2016) found hands-on active learning workshops useful, Blount et al. (2016) pointed out the need for technical and pedagogical support to educators to achieve learning outcomes, Alshare et al. (2015) identified student effort as critical, and Seethamraju (2007) found significant improvement in accounting students' process orientation and conceptual understanding when ERP technology is used as an active learning enabler. It is, however, considered a dual challenge to make the accounting course relevant by incorporating skills that are relevant to industry, while designing the curriculum and implementing innovative active learning methods enabled by technology (Mortias et al. 2006). Wijaya (2023), based on a systematic review of literature, argued that ERP technology enhances active learning, improves understanding of process integration, increases career opportunities for students, and noted that the implementation is constrained by the inadequate IT infrastructure, staff skills and students' lack of understanding of business cycles.

Such TEAL initiatives which use industry standard technology tools as enablers, could be led by an instructor or self-paced, and can facilitate individual or team-based learning (Gupta and Bostrom 2009). Individualizing the technology adoption by engaging every student with technology, when compared with the grouping of individuals that require sharing of technology, it is argued, would have more positive effect on students' cognitive learning (Shi et al. 2020). Studies have observed that transparency of the learning process, quality of exercises and materials, interactivity of the technology

(Sollner et al. 2018) and adaptive learning paths matching the expectations of individual learners (Shi et al. 2020) are the drivers of effective TEAL.

Technology-enabled active learning (TEAL), however, requires self-discipline and is dependent upon the effort exerted to achieve learning outcomes effectively. It is criticized for not effectively facilitating 'deep learning', especially when students lack intrinsic motivation to acquire knowledge and skills from technology-enabled platform (Martens et al 2007). An analysis of literature by Borte et al (2023) identified several barriers to active learning. Some of the key barriers identified include inadequate technology infrastructure, teachers' workload, lack of commitment by academic staff, limited professional development, little personalisation of learning and assessment practices, stress due to increased student expectations, complexity of technology, and students' inability to utilise the interactive potential of the technology (Borte et al 2023). If the technology is not aligned with the subject content and does not offer possibilities for interactive engagement, collaboration, communication, and feedback, learning effectiveness will be constrained.

Despite their positive influence, use, and popularity over two decades, active learning methods are not the most common approaches being utilised in higher education (Stains et al. 2018). Benefits of active learning approaches on student achievements were studied in areas such as science, engineering, and technology, but in business education context they are limited (Alqasa and Afaneh 2022). Despite frequent calls for change to student centered active learning by leaders, researchers, policy makers and students, there are limited instances of active learning environments in higher education institutions in general (Borte et al 2023). Emphasizing the student centered teaching method, its experientialism, and its positive influence on learning experience and outcomes, Tettamanzi et al (2023) called for a shift towards technology enabled active learning approaches in higher education. Though to a lesser extent, past research on active learning pedagogies was in STEM (science, technology, engineering, and mathematics) courses (Ruizo-Primo et al. 2011) and initiatives and studies on the implementation of technology-enabled active learning (TEAL) initiatives in business are rare (Shi et al. 2020, Apostolou et al 2022).

Research on the impact of Technology-Enabled Active Learning (TEAL) initiatives on students' cognitive learning outcomes has shown mixed results in the past (Shi et al 2020). While studies in the classrooms of social work, by Blazquez et al (2019), in biology by Parishan et al (2011) and in nursing by Welch (2013), have reported significant improvement in students' cognitive learning, others such as Mendini and Peter (2019) in marketing, and Baepler et al (2014) in computer science classrooms, did not see any significant differences compared to traditional learning environments. A study of a physics classroom reported improvements of cognitive learning outcomes during the first semester, but not in the second semester (Shieh et al 2010). While Rashid and Asgar (2016) found positive relationship between technology use and self-directed learning and engagement in a study of undergraduate students, no significant relationship between technology use and academic performance was observed. Thus, as argued by Alcalde and Nagel (2019; Borte et al 2023), active learning methods though exhibiting greater student satisfaction, have mixed impacts on student achievement.

Despite the known potential, how these technologies are reshaping learner's motivation goals, learning abilities and interactions is not known (Shroff et al., 2023). Though problem based learning approaches in technology contexts are increasingly employed to develop higher order critical thinking and interactive problem solving skills (Unal and Cakir, 2021), and received scholarly attention (Hafeez 2021 and Tam 2021), technology-based active learning approaches have not been empirically integrated into learning environments (Shroff et al 2021). Past research on active learning tends to be based on 'local evidence and experiences', mostly from US, and evidence on the effectiveness of the approach is insufficient (Betti et al 2023). A report by the Norwegian Ministry of Education and Research called for further studies to investigating the characteristics of beneficial technology enabled active learning and the influence of attributes such as knowledge scaffolding, social factors, feedback, and assessment on the learning outcomes (Lillejord et al 2018).

In addition to the limited research on TEAL in business education as discussed above, professional bodies also are asking accounting educators to provide active learning opportunities to students with creative integration and use of technology in the accounting curriculum (Fratto 2011; Betti et al 2022). For example, CPA (Chartered Professional Accountant) exams now add more emphasis on technology from the year 2024 onwards and requires faculty members to prepare students better on technology (Apostolou et al 2022). The AACSB (2022) standard A5 requires development of skills and knowledge related to the integration of technology, and adoption and mastering of the current and emerging technologies by the accounting students. Investigating the accounting students' learning needs in Australia, Daff (2021) identified the need for students to be equipped to think logically about data, recognise how transactions are processed by accounting software, identify inconsistencies, and tailor reports from the software to user needs and recommended the integration of accounting software throughout the accounting curriculum.

Mixed research results on TEAL in the past, limited empirical evidence on the evaluation of TEAL initiatives in accounting and business education context, increasing calls for research by researchers, accounting professional bodies and practice, lack of knowledge on the influence of interactive engagement, feedback, stimulation of interest, individualisation of learning process – all enabled by the business technology, discussed above and an alternative content delivery methodology for teaching management accounting concepts and processes (as advocated by Apostoulou et al 2022) are the motivation for our study. Responding to these, our study investigates the effects of a technology-enabled active learning initiative while teaching management accounting. Our study incorporates enterprise resource planning (ERP) technology as an enabler in the learning of management accounting concepts and processes, and a theoretical framework proposed by Shroff et al (2019) that contains most of the factors (interactive engagement, feedback, interest, collaborative problem based learning, social factors, individualisation) raised in the literature. The next section explains the theoretical anchor used in this study.

3 Theoretical Anchor

Rooted in constructivist learning theory and social constructivism, active learning includes learning by connecting new information and experiences to prior knowledge allowing students to construct new knowledge through collaborative and cooperative learning, and peer to peer interactions. Based on adaptive structuration theory (DeSanctis and Poole 1994), Gupta and Bostrom (2009) developed a theoretical model for technology mediated learning that configures elements of the learning process including team, technology and learning structures. The framework consists of learning context characterised by the structures of technology, teams, learning techniques and scaffolds; and learning method that consists of goals and epistemological perspectives, and the learning process that involve technology appropriation and the relationships between them (Gupta and Bostrom 2009). Testing their model in an IT-training context, Gupta and Bostrom (2013) investigated the appropriation of technology-mediated training methods by incorporating enactive and collaborative learning and demonstrated positive results on all training outcomes. This framework, applied in industry context, however, does not explicitly address the active learning dimensions such as engagement, feedback, and interest relevant in higher educational learning context.

Integration of digital technologies such as mobile phones, ERP systems and Analytics solutions into learning environment enable problem solving, interactive cognitive engagement, collaboration with peers and teachers, and inquiry-based discovery and enhance the role of technology in supporting active learning strategies. We therefore have chosen a framework proposed by Shroff et al (2019) that has all the four domains of active learning. This framework encompasses social, cognitive, affective, and evaluative domains of active learning. "*Learner interactive engagement in the learning process, problem solving skills that require cognitive complexity, activities that evoke interest and that require an exercise of judgement in the face of uncertainty, and activities that encourage feedback*," are the core elements in this framework (Shroff et al 2019: 113). We therefore used this framework as our theoretical anchor to analyse the perceptions of students on our technology enabled active learning initiative. Each of the four constructs contextualized to our study by referring to the learning of management accounting concepts and processes, and enabled by ERP technology are explained below.

Interactive engagement is defined as "*the learners' engagement with the course content, other learners, the instructor, and with the technological medium used in the course*" (Thurmond, 2003, p.238). Interaction, a key variable of active learning is found to be effective in technology-based education (Huang & Liaw, 2018). The adoption and use of ERP technology such as SAP can support a broad range of learning activities to create meaningful learning experiences (Chang et al., 2017). Interactive engagement in our study is designed using lectures, hands-on workshop with technology, and online discussion forums for interaction with peers and academics, for learning to take place. It refers to the extent the learning environment facilitates responsive engagement with peers and teachers through skilful interaction with features of technology and its interface.

The second dimension, problem solving involves students analysing information and formulating judgments through their problem-solving skills within their cognitive domain - accounting. It is a process of actively interpreting, analysing and evaluating all perceived information and the technology-based activities that are designed to support problem solving skills and require learners to engage in analysis, synthesis and evaluation (Shroff et al 2019). Students are expected to analyse the business scenarios, interpret information provided, define the problem by viewing it from multiple perspectives, and relate that to the management accounting concepts and processes embedded in the technology by analysing one's own views and to solve problems by mapping data, executing relevant transactions and producing reports.

Interest, the third dimension is designed to explore the options available to students when navigating user interface and dealing with challenging tasks. Learners are more likely to be engaged in authentic and meaningful ways if the activities could stimulate interest and curiosity in performing a task and challenge the learners to draw learning and skills (Schraw and Lehman, 2001). Using SAP technology that has internal controls, checks and balances built for a real-time commercial business organization, is expected to stimulate interest and curiosity, encourage them to explore options and perspectives, pay attention to issues they may not have otherwise thought of, to exert effort and to persist on challenging tasks.

The fourth dimension, feedback involves receiving input and feedback from each other, from academic staff and from the technology itself, to understand and correct errors, and improve performance and reflect the evaluative domain of active learning. Feedback here denotes the extent technology-mediated active learning allowed a student to receive timely feedback to assist them in tracking progression towards knowledge acquisition, mastery of skills and learning, and furthering their understanding and consolidation of management accounting concepts and processes.

4 Methodology

This evaluative study was conducted at an Australian university business school. Aligning with the goals of accounting education, and active learning pedagogy, an enterprise-wide accounting system was used to give students a 'hands-on' active learning experience. Considering the limited time allocated for this initiative within the curriculum, vastness of accounting functionality in an ERP system, increasing importance of the allocation of indirect costs and their tax significance in business firms, cost allocation functionality of SAP was considered important and embedded in the curriculum.
Learning was designed in three stages. First stage involved pre-reading of the materials, two lectures in consecutive weeks explaining role of ERP system in business, terminology, features, functionality, data structure, organizational configuration related to the management accounting processes, allocations, and reports. Second stage includes testing the understanding of concepts through an online quiz with feedback, demonstration of technology by academic staff and 'hands-on' workshops with individualized attention and support to students. In these workshops, students map the business scenarios in the system by creating master data, performing accounting transactions, interacting with cost information and producing relevant reports. In addition to the individualised support in the workshops, students are given help and guidance outside the workshop times through Canvas – a learning management system. The third stage was a significant assignment with group and individual components. The group component required students as a small group analyse, evaluate, and design management accounting data, tasks and processes and recommend managerial decision. The individual component required each student to determine, identify, create and execute data, management accounting transactions and processes such as allocations and produce appropriate reports.

All students enrolled in the undergraduate 'Management Accounting' unit were asked to voluntarily submit their written reflections on the initiative at the end of the semester using a semi-structured questionnaire. This questionnaire aimed to capture students' perceptions on the TEAL initiative and specifically on the role of technology (SAP ERP software in this instance) in their learning. The theoretical framework by Shroff et al (2019) was applied to collect data as well as to inform the analysis of students' perceptions. The questionnaire has five broad open-ended questions, with each question seeking perceptions of students with reference to the way the initiative had facilitated interactive engagement, developed problem-solving skills, generated interest and curiosity to learn, and provided feedback and their contribution to learning. Further, they were asked to reflect on the challenges they faced in understanding the links and relationships between the functionality of technology, management accounting processes embedded in technology, lectures on management accounting and the scaffolded learning support at three stages designed in the learning environment.

Out of a cohort of 221 students, 84 students provided the response. After removing 28 responses that were incomplete, 56 responses were available for analysis. These responses were then anonymized and made available to the authors for analysis only after the grades were received by students as per the ethics protocol. These reflections were analyzed and coded independently by the two authors according to Shroff' et al (2019) framework using a qualitative data analysis software NVivo. The authors categorised their responses broadly into five groups: interactive engagement, problem-solving skills, interest, feedback and overall challenges. Differences identified in coding were reconciled through discussions and results are compiled.

5 Analysis, Discussion & Findings

This section presents evidence from individual reflections based on the analysis of how technology-enabled active learning influenced the learning process and impacted learning. Findings are organized with focus on each of the dimensions - interactive engagement, problem solving, interest and feedback.

5.1 Interactive Engagement

Our study revealed a direct and positive relationship between the use of technology in learning and engagement and self-directed learning. Confirming the findings from a previous research by Rashid and Asghar (2016), we found students' engagement is facilitated by the technology in the second (workshops) and third stage (assignment) of the learning process and resulted in effective learning. Interactive engagement with the content, teacher, peers, and technology at different stages helped students construct knowledge and lead to active learning. This has helped students create meaningful learning experiences with regard to what they have learned and how they have demonstrated mastery, confirming the work by Chang et al. (2017).

Initially, before being exposed to technology, some students felt confused and found it difficult to understand the context and new terminologies. While some felt they were "*stumped as it seemed full of new terminology, difficult to understand the business scenario because of this (new terminology)* (R22). Though they *"appreciate the relevance of SAP as a management accounting tool,* they found it "*a challenge to link management accounting concepts with a technology*" (R08). Some students, our study observed are reluctant to read the materials before the class, listen to the lecture or invest time and effort to interactively engage with technology, thereby making it harder for themselves. One student confessed: "A*s I had not read the instructions and concepts clearly at first, I blindly followed the steps shown in the SAP exercise and felt tedious after the 3 hours workshop"* (R30) and did not notice any learning benefit. Thus, individual motivation to engage with the materials and technology played a moderating role, our study observed. Where there is no intrinsic motivation, the initiative, it appears do not contribute to learning and is a major barrier (offering empirical evidence to the views/propositions of Martens et al 2007 and Borte et al 2023).

For those students, who have actively engaged with the technology in workshops through learning activities, materials, and received individualized support and guidance from teachers, their understanding and learning improved significantly. A student confirmed this: "*Through engagement with the technology in the workshops and assistance from the lecturer I am able to understand the SAP program very comfortably*" (R16). Another student observed that "*the effects of the hands-on SAP workshops are positive, gave me the opportunity to operate the accounting system myself, and the practice improved my knowledge and skills and helped me to have an exact idea of the way it operates*". (R17). Another student observed: "*initially it seemed immensely complex with countless number of accounts, folders, menu paths and tabs, I found it extremely difficult to comprehend as the numbers did not make sense to me and I was not able to go back when I wanted to. In the second workshop, however, I was able to navigate more quickly*" (R35). Thus, gradual increase in engagement through scaffolded support contributed to learning.

"*Using the accounting system in the assignment required me to re-examine what had been taught in the lectures and workshops and apply it to a different scenario. I believe this was much more interesting and challenged me to learn more about the workings of the system.*" (R04). Another student found "*using the technology unguided as the most helpful approach towards learning and reinforcing information obtained from the workshops and readings.*" She/he observed that, *"the assignment provided an avenue to fully utilise what we had learnt from the workshops and apply it to a case study.*" (R12). Another remarked that: "*The hands-on workshops provide a perfect environment for me to follow instructions, interact with technology, and learn new skills, as well as being in a supportive environment"* (supported by teacher and peers) (R29). Therefore, interaction and engagement with materials, teachers, peers and technology have not only delivered individualized learning, but also provided students with an opportunity to enhance learning effectiveness. The adaptive learning paths that match the expectations and requirements of individual learners in our TEAL initiative is a significant factor in student learning, our study found. It validates the view of Shi et al (2020) empirically.

5.2 Problem solving

Various authentic learning activities enabled by technology and embedded in the learning context have helped students to view problems from a deeper perspective and develop their critical thinking and analytic reasoning processes, confirming past research by Shroff et al (2019). Students gradually developed an understanding of the connection between SAP functionality, management accounting processes and business scenarios and started building the necessary problem-solving ability required for the assignment. One student stated: "*Despite learning from reading materials and lectures, completing the second workshop with the use of SAP strengthened my understanding and connection with management accounting and the real-world accounting procedures; initially, I only have a general concept about SAP after attending the lecture; working on the exercises in the workshop, I gradually build my understanding of SAP.*" (R07). The first workshop, however, did not give them enough understanding and students "*haven't got the chance to link theory content to SAP processes even though they have stayed 100% focused and tried to follow every single step*" (R36). Students felt that they did not have enough time in the workshop to clearly understand what they were doing and develop problem solving skills to know why they were doing what they were doing. One student stated: "*Due to limited time spent in workshops, it is difficult to completely comprehend the reasoning behind each step and solve the problems given in the assignment*" (R27). However, by revisiting their reading materials, and practicing more, students were able to develop their problem-solving skills required for the assignment. This finding offers new insights on how the motivational goals and abilities of learners change and contribute to improvement in problem solving skills based on interaction - hitherto not studied and known (Shroff et al., 2023).

A student noted that they "*had to actually sit down with the reading materials next to the workshop exercises to properly understand the processes of SAP and when to use certain features e.g., the different allocation methods*" (R20). After completing the assignment, students *"felt comfortable and well familiarized with the technology and management accounting and concepts such as cost centre, cost group, cost elements, statistical key figure, and variance analysis.*" (R18). These analytical and problem-solving skills were developed further when students were on their own completing the assignment, wherein they were able to put to use the deep learning they had obtained from reading materials, lectures and workshops. As observed by a student, "*active critical thinking and analytical skills were finally utilized and tested in interpreting the results garnered through the assignment."* (R15). As noted by a respondent, "*active learning enabled by SAP technology helped us develop critical thinking skills that we have used in the assignment; it gave us the opportunity to practice what we were taught during the workshops and tested our limits and understanding of technology*" (R25). "*The assignment enhanced my critical thinking and ability to finish tasks individually – a skill really useful for my future career and employability*" (R02). Thus, the technology-enabled active learning activities and processes embedded in the learning context, helped students develop problem solving and critical thinking skills and contributed to learning. This TEAL not only helped students learn management accounting concepts and processes, but also gain critical analytical and practical employability skills. This finding demonstrates positive contribution of TEAL to learning by enabling improvements in learners' problem solving and critical thinking skills (Bedenelier et al., 2020; Shi et al., 2021; Shroff et al., 2023).

5.3 Interest

Students were engaged in meaningful ways especially from stage 2 (workshop) as it started to stimulate their curiosity and interest. Workshops with the help of facilitator, and assignment on its own, required students to explore various options while navigating the user interface and exert effort as they face difficulties by persisting at the tasks that are at times challenging. Like problem solving dimension, interest, we found, was also developed in a gradual manner starting with little or no curiosity in the first two phases – pre-reading and lectures, and then the interest developing in the hands-on workshops and finally reaching to higher levels while doing the assignment.

As each student was required to map his/her unique data in the system, perform relevant transactions and produce reports through exploration and discovery of the features and functionality, their interest was stimulated. The assignment (stage 3) challenged them to draw on their learning from the unit and preparatory materials and lectures (from stage 1). Students were challenged as they face difficulties while figuring out the data, transactions and processes in the system and linking it with the management accounting concepts and processes learnt in the unit. A student observed that "*workshops gave us opportunity to explore on our own; facilitator and tutor would only assist us when we face some problems; this is a good active learning experience doing almost on our own*," (R19).

Interrogating the technology not only generated interest in the learning, but also made students more curious to explore and exploit technology more – well beyond what is required in the curriculum. As pointed out by a student, "*making some mistakes, trying to find a way out by doing the least amount of work, and finally getting to the correct reports – have all are challenging and increased my interest and understanding*" (R10). As noted by a student, "*after the required exercise, I explore a little bit more and discovered new features and new capabilities - enabling communication between employees in different departments without the transfer of information in traditional way*" (R10).

The more they have interacted with the technology beyond what is required as per the curriculum, the better their confidence to explore new tools, new functionality and new learning. As observed by a student, "*the kickstart was strong enough that I don't have to consult teachers all the time, but (*at the same time) *not too strong such that I lose the curiosity* (of learning)" (R31). A student reported that "*I discovered a range of different reports that can be produced by the system which has not been talked about in the lecture or in the reading materials or in exercises; these reports can be very useful*" (R27), thereby attesting to the important role of interest and curiosity, enabled by the technology in improving learning effectiveness.

Students seemed concerned why corrections cannot be easily made in the system. Once they understood that the built-in internal controls in a real-time accounting system don't allow deletions or alterations, they have appreciated this aspect and were cautious while working on the assignment. This led to an improvement in their concentration and deep learning, resulting in a better understanding of how the software works in relation to management accounting. One student observed: "*the difficulty surrounding the remedy of any mistakes, encouraged me to be more conservative and methodical in my approach to completing the tasks. I believe that my interaction with the technology (SAP) has helped me gain considerable insight into the management accounting processes*" (R14). Although the case study assignment did not provide any step by step guidance, students were able to figure out the processes with their interest and curiosity to learn and demonstrate their skills in the assignment. As acknowledged by a student, "*by having to work through a case study that did not directly outline what to create and what method and which process to apply for each element, I was better able to analyze what the assignment was asking, and how I could best deliver the desired resul*t" (R26). Thus, as they made progress, they were able to discover capabilities of technology and learn. Thus, the interrogation of the technology "*gave us* (students*) a chance to explore the system for ourselves and try new options we hadn't touched before and knowing which ones not to take*." (R23).

Students acknowledged that the assignment was challenging and required them to exert additional effort and persist at the tasks that are challenging. effective role played by the challenging tasks expected from the learning context, especially when completing the individual assignment. One student aptly summarized this: "*at first this (assignment) was difficult, because there was no guide to follow, however, this relates to reality where we won't always be spoon-fed. Having this assessment that way gave me a strong sense of challenge to understand, explore and work with the technology to understand accounting and appreciate it much more*" (R28). Thus, the context and the process enabled by the technology in our study, has challenged the learner's present cognitive schema, generated task-based interest (Chin and Wang, 2021) and made the learning more meaningful and long-lasting. Our technology enabled active learning context has increased student's sense of curiosity, placing the individual in an active role of exploration, investigation, discovery, and application, enabling him or her to use the technology in meaningful ways and contributed to learning. This new insight extends Shroff et al (2021) framework, by identifying the importance of learners' ability to exercise a sense of control through exploration, navigation, discovery and application.

5.4 Feedback

Feedback is critical in technology-mediated active learning because it allows students to receive timely feedback on their performance and helps them keep track of their progress. This feedback enabled by the interactive technology in our study, enabled learners to reflect on their learning processes and helped them subsequently develop critical thinking and problem-solving skills as explained in section 5.2. Context sensitive feedback enabled by the technology and provided by the facilitators in the workshop as well as online during the assignment period (stage 3) in our study, has increased the students' motivation and engagement.

Though there was no was no feedback in the first stage (i.e. pre-reading and lectures), students received individualized feedback during the workshops and assignment. This helped them develop mastery of skills and consolidate their learning by gaining a better understanding of the management accounting processes enabled by the technology. The technology itself gave feedback with advice to correct the errors when committed along with an explanation of the error, possible causes and potential subsequent action individual student could take. Students found it useful. A student comments that "*the most important feature of the technology is audit/error trail; every time I doubt the correctness of the numbers, the audit trail works as a useful tool to track the specific amount and see where and how I entered it, so that I can correct the error.*" (R24). Additionally, "*it (technology) also noticed mistakes and errors and informed us to correct it; helping us to understand the processes better*". (R13).

During the workshops, some who were "*new to the technology and cannot read the instructions properly, don't understand the error messages provided by technology; tutors helped us a lot; she emphasized on dealing with mistakes many times and gave us strong support; every time we did not know a specific process, she would teach us patiently, then it made more sense*" (R33). Some, however, felt that the feedback was inadequate or missing. A student observed: "*workshops allow us to receive real-time feedback not only through error functions imbedded within SAP, but also through the tutor, who was able to walk through certain aspects of the workshop in a methodical and detailed manner.*" (R38); and "*asking a lot of questions and getting instant feedback from the lecturer, helped me with my understanding significantly,*" (R06). Attributing this to the limited time allocated to hands-on workshops, some students opined that "*instead of completing lengthy practice exercises over two workshops, a third workshop could be added and devoted to completing the assignment in the presence of tutor capable and willing to provide engaging and troubleshooting and feedback and aid in real time.*" (R37). Another felt that "*I was able to grasp my weaknesses when I made mistakes and get help and feedback from tutor; my experience of this was positive and I enjoyed working hands-on with the tutor while being taught at the same time. It was definitely more interesting and engaging than a regular class.*" (R39). Peer support also helped some students, especially during the assignment stage. As noted by a student, "*together with the support of my peers, we came up with an effective strategy. I took this confidence into the individual components of the assignment, which turned out to be less of a difficult task than I thought.*" (R34). Overall, feedback enabled by technology and the learning processes in our study, not only drove the learner towards expected learning outcomes but also helped them learn from their mistakes.

6 Conclusions

Our study investigated the influence of technology-enabled active learning on learning and demonstrated the positive influence of interactive engagement, problem solving and feedback, confirming past research by Su and Cheng (2015), Shroff et al (2021), Shi et al (2020) and other scholars. Importantly, our study uncovered the critical role of the individualized adaptive learning context enabled by the technology and addresses some of the inconsistent findings in the literature on TEAL. Our study establishes the relationships between the key dimensions of TEAL and demonstrates the influence of scaffolded learning context, interactive engagement and ongoing feedback enabled by technology on learning, student's interest in exploration and discovery, all leading to the development of problem solving and critical thinking skills.

As our study demonstrated, technology, though can provide the tools to promote active learning strategies (Nicol et al. 2017), it cannot by itself deliver outcomes and effectiveness without prompt feedback (Martyn 2007, Freeman et al, 2014), accountability that requires students to apply problem solving and critical thinking skills to authentic situations created in the learning environment (Shroff et al., 2019; Chi and Wylie, 2014), and, a sense of challenge and curiosity in the designed learning activities (Mozelius et al. 2017; Shroff et al 2021). The active learning strategy enabled students to learn the practical side of management accounting making the unit interesting and engaging and contributed to greater levels of relatedness with peers and instructor. Our study reveals that although technology enabled active learning increases student's control over the timing, pacing and sequencing of their learning, it also demands greater student responsibility and effort.

Our study demonstrates the effectiveness of TEAL in accounting context, contributing to the gaps in the literature. It offers guidance to other business schools on how to integrate business technology within active learning and cater to the individualized learning requirements. Considering that the students' background characteristics are reasonably representative of a typical undergraduate accounting students in Australia, our study results may be useful to other academic staff in designing and implementing TEAL to make learning interesting and engaging. Further studies on the influence of moderating variables such as class size, complexity of technology, domain knowledge, and the sense of control exercised by students are needed.

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