Increasing learner engagement in, and performance of, technical threshold concepts in accounting and finance education through a gamified learning experience

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Declaration of Originality

I declare that this is my own work and has not been submitted in any form for another degree or diploma at any university of other institution of tertiary education. Information derived from the published or unpublished work of others has been duly acknowledged in the text and a list of references is given.

Statement of Authority of Access

Statement Regarding Published Work

Portions of Chapters 3 and 4, and Appendix 1 in this thesis have been published by the researcher in modified form in the book chapter, Making a game of troublesome threshold concepts, in D. Ifenthaler, & Y. Kim (Eds), *Game-based assessment revisited: Advances in game-based learning*. (Wood, K., 2019). Due to the inclusion of published material there is unavoidable repetition of material between chapters in this thesis.

Certification of intention to use the Index of Learning Styles© (Richard Felder and Barbara Soloman) for educational or research purposes was obtained from Education Designs, Inc., Cary, NC, USA. For information about the history of the ILS, the theory behind it, appropriate uses of it, and studies of its reliability and validity, see www.ncsu.edu/felder-public/ILSpage.html.

Statement of Ethical Conduct ECN-17-229

The research associated with this thesis is in accordance with the National Statement on Ethical conduct in Human Research. The National Statement is developed jointly by the National Health and Medical Research Council, the Australian Research Council and Universities Australia. Human Research Ethics Committee (HREC) approved this human research conducted at Southern Cross University (ECN-17-229).

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Abstract

Meyer and Land (2006, p. xiv) stated that the "resolution of troublesome knowledge challenges and forces conceptual thinking via a transformative portal of a threshold concept." To explore the resolution of threshold concepts via a gamified learning experience this research was situated within the academic standards of skills and knowledge for accounting and finance students, in line with the competency requirements of the professional bodies (Hancock et al., 2016). This aligns with Kennedy et al.'s (2009) advice that emerging technologies and improved student learning activities, assessments, and outcomes are best managed and aligned with pedagogical, technical, and administrative knowledge.

This research used the pedagogy of the gamified learning experience (GLE) design to identify what learning conditions support gamification, the gamification features that lead to learning, and how can they be integrated to ensure learning outcomes are met. The theoretical framework for this research was centred on constructivism, encompassing social constructivism and cognitive learning theory, and encapsulated by Laurillard's (2002) conversational framework. This was used as a methodology for exploring the interactions and relationships that take place in the GLE, and how these contribute to learner engagement in, motivation for, and performance of learning.

The application of the treatment GLE only demonstrated a significant relationship between participant self-efficacy with the technical threshold concept of the time value of money (TVM) and the GLE, and not between engagement with the content or assessed learning outcomes of the technical threshold concept of TVM and the GLE, however, the data collected has provided insight into the student experience and performance. Multivariate ANOVA was used to examine the learning experience and outcome results to make inferences about the hypotheses of learner engagement, learning success, and self-efficacy. This multivariate ANOVA method and GLE design

framework were then used to evaluate the imposition of the GLE treatment as a pedagogical resource in accounting and finance technical threshold concepts. Due to unexpected insignificant results from the initial analysis, a secondary analysis was performed which focused the investigation on the survey items pertaining to testing the student learning experience within the GLE, not testing the game itself. After removal of 18 items which measured the design of the game, 12 learner focused items persisted to become eLearningGameFlow: a new learner centred tool for measuring students' learning experience in the game.

The use of eLearningGameFlow will potentially allow learning designers to not only do their best creating GLEs which deliver an equal or somewhat apparent approval in learning outcomes, but also increase student use and learning engagement of the GLE as a pedagogical resource. As a learning testing tool, eLearningGameFlow may assist in identifying and measuring the actual learning points for replication.

Chapter 1 – Introduction

1.1 Overview

The original motivation for this research was a perceived need to bring learning and teaching into line with the expectations and tools of the digital age and culture so that student engagement with learning is enhanced (OECD, 2016). This was described by Thomas and Seely Brown (2011) as a new culture of learning that signalled a shift in thinking from the old model of teaching to a new model of learning. Within this space is the gamification of curriculum. Gamification is the application of game-design elements and game principles in non-game contexts (Kapp, 2012). Far from being unstructured play, a gamified curriculum demonstrates highly organised, achievement level, quantifiable learning. Deterding et al, (2011) expanded the definition of gamification, from just play, to focus on teaching educational content and improving skills. They defined gamification of the curriculum as a process of using game elements in non-game contexts; that is employing *serious* games to operationalise learning and motivation theories (Grund & Meier, 2016).

As an extension of Biggs' (1987) and Biggs and Tang's (2011) constructive alignment, and combined with Tasker's (2012) concept of cognitive learning where constructivism meets reflection, the research objectives were to show how, for technical threshold concepts in accounting and finance, student engagement in learning and learning outcomes could be enhanced by a gamified learning experience, and how using the principles and framework of gamification could enhance student efficacy and contribute to learning design. This research draws on the definitions of engagement in higher education from Coates (2006) who stated "student engagement is concerned with the point of intersection between individuals and things that are critical for their learning" (p. 17) and further from Barkley (2010) who reported "student engagement as a process and a product that is experienced on a continuum and results from the synergistic interaction between motivation and active learning" (p. 8). Learners become active participants in determining their own learning trajectories, are motivated to succeed, and engage deeply in learning the content, within the boundaries negotiated with the teacher. The teacher is a mentor in the learning process, guiding students to seek their own destinations. These destinations represent individual knowledge acquisition achievements and achievements of outcomes, each of which can be unpacked and assessed using criterion-referenced assessment (Lok et al., 2015).

The gamification of curriculum represents a new approach to teaching in the professions that warrants greater scrutiny (Matthews, 2010; Mbodila & Muhandji, 2012). The Australian professional bodies identify critical thinking as a desirable graduate attribute, to be developed within curriculum that incorporates technology for active learning. As a lens to look at this potential revision of pedagogy through curriculum reform, this research uses gamification to reimagine accounting and finance teaching and test how game-based learning can be used to create effective learning experiences in an online environment. This is done specifically for one core technical threshold concept (Lucas & Mladenovic, 2009; Meyer & Land, 2006) that is a foundation of this discipline. The research was designed to evaluate the effectiveness of a gamified curriculum and pedagogy for delivery of the technical threshold concept, time value of money (TVM). The findings of this research will assist educators to further develop and measure gamified learning pedagogies relevant to other threshold concepts in a range of discipline areas.

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In April 2010 the first iPad was released. At that time, being in academia and working in a central teaching and learning department, I saw discipline academics, from medicine to games design, toting around these first versions and touting their features and benefits. One particular academic discarded her Kindle and downloaded the Kindle app on her iPad. Her first eBook purchase was Thomas and Seely-Brown's (2011) "A New Culture of Learning". This new culture of learning presented a new way of looking at curriculum design, likening curriculum to a petri dish. Where biologists use a shallow dish that holds a growth medium to culture cells, teachers were now encouraged to provide a fluid but contained learning space where students created their own learning trajectories. This was the most exciting teaching and learning idea we had seen.

This was also at the time when teaching academics were tentatively experimenting with personal response systems - clickers - in their classrooms, for interactive real time response and assessment by “provid[ing] immediate, real-time feedback to students in even the largest lecture hall, directly influencing student learning” (Wolter et al., 2011, p. 14). Generally, the use of these social interaction technologies was being seen as providing egalitarian representation in the classroom. More technically adept academics, my colleague in particular, were designing game-like quizzes used via apps on students’ own mobile devices and live in the classroom.

Coming from professional accounting practice, dealing with client advice and education, I always described myself as the user-friendly accounting teacher. I prided myself on being able to teach anyone accounting in a relevant, applied way – and having them enjoy the process. My lived experience was as a student and then teacher in economics and accounting, and I wondered over many discussions, and peer observations of teaching and student engagement with learning, how these technology-enhanced learning resources could be incorporated into the traditional business classroom.

After percolating for some time, these facets that so excited my pedagogical brain eventually came together as the gamified learning experience that is the central feature of this research.

* * *

1.2 Context

This research was conducted against the background of the academic standards of skills and knowledge for accounting and finance students, in line with the competency requirements of the professional bodies (Hancock et al., 2016). This aligns with Kennedy et al.’s (2009) advice that emerging technologies and improved student learning activities, assessments, and outcomes are best managed and aligned with pedagogical, technical, and administrative knowledge.

Meyer and Land (2006, p. xiv) state that the "resolution of troublesome knowledge challenges and forces conceptual thinking via a transformative portal of a threshold concept." They identify the need for further research into this state of liminality, the threshold, akin to Vygotsky's (1978) zone of proximal development or the production possibility frontier of Keynesian economics, where learners experience a shift "to a new status or thinking pattern … becoming conscious of thinking like an accountant" (Meyer & Land, 2006, p. 31). Liminality, from the Latin *limen* translated as threshold (Simpson & Weiner, 1989), also relates to the transition region between conscious thought (supraliminal) above the threshold (https://www.merriam-webster.com/dictionary/supraliminal) and subconscious thought (subliminal) below the threshold (Loftus et al., 1992). Existing mental models are often stored subliminally in long-term memory and provide our bedrock understanding of elements of the world. It is the conscious, supraliminal thought that brings those models into the light and inspects them. When we experience something that requires us to challenge our subliminal models and eventually change them, then that moment when a model is challenged or found to be missing gives us pause in the liminal zone before making conscious changes (Rutherford & Pickup, 2015). It is at this point where the student is readied for accepting new understanding and for learning to occur. Here the teacher needs to understand where the learner is in the understanding of the threshold concept (Heading & Loughlin, 2017). There is often panic, disorientation, and loss of confidence, all before leading to an acceptance of change and drive to make new sense of the world (Barrow et al., 2020).

Finding ways to ease the passage through the liminal zone and facilitate core learning is an ongoing challenge for educators (Meyer & Land, 2006). To investigate learning with the liminal space, Cousin (2008) advocated for collaboration between content experts, students, and educational researchers in a "pursuit of shared understandings of difficulties and shared ways of mastering" threshold concepts and an approach "which becomes neither student-centred nor teacher-centred but something more active, dynamic and in-between" (p. 270).

Land et al. (2014) in their paper about threshold concept learning in the liminal space suggested that the role of context was key, stating that it "presented an opportunity … for the disciplinary specialist in university teaching to open up a dialogue with his or her students, and to pursue routes of inquiry into the nature of their understanding of particular phenomena in specific contexts" (p. 215). Specifically referring to the challenge accounting students face in "grasp[ing] the terminology and fundamentals of the discipline quickly in order to understand and apply concepts successfully" (Moncada & Moncada, 2014, p.10), Moncada and Moncada (2014) observed a scarcity of gamified learning experiences and suggested the use of available software could be used to create learning games.

The four fundamental threshold concepts in accounting and finance are commonly identified as: (1) the accounting equation, (2) debits and credits, (3) the time value of money (TVM), and (4) risk and reward (Berk el al., 2014; Carlon et al., 2018; https://www.charteredaccountantsanz.com/, Parrino et al., 2016; Sutherland & Canwell, 2004). A single accounting threshold concept that could be encapsulated and developed for teaching, as a discrete piece of learning, was needed to provide a defined and measurable object for the variables of this experimental research. Time value of money (TVM) was chosen as the technical threshold concept for this research. Accounting and finance educators must teach technical core concepts, the understanding and application of which, are essential for a professional career in accounting and finance. TVM, one of the foundation core concepts, is arguably the most fundamental component of, and central to, financial education (Dempsey, 2003; Newfeld, 2012; Stuebs, 2011). Students need TVM valuation and measurement skills to prepare for professional life. However, few accounting and finance concepts are as challenging to teach and learn as TVM (Dempsey,

2003) and therefore many different pedagogies have been developed (Dempsey, 2003; Eddy & Swanson, 1996; Jalbert, 2002; Stuebs, 2011).

1.3 Gamification and gamified learning

This research uses the term *gamified learning experience* (GLE) to describe the pedagogical practice of using gamification for learning. One of the most common challenges for a GLE is the test of being pedagogically sound (Arnab et al., 2013). Can learning happen in games? Is it different to learning from a teacher? Is it better?

Gamification commonly employs "game thinking, approaches, and design elements" (GamifyingEducation.org), which are used in so called non-game contexts (i.e., curriculum and learning activities) in attempts to improve learner engagement with content (Kapp, 2012), learning outcomes (Anderson, 2001; Bloom, 1956, Churches, 2009), flow or continuity (Csikszentmihalyi, 1990), self-directed learning (Goffman, 1961; Juul, 2005; Koster et al., 2004), and ease of use and usefulness (Davis, 1989) of learning resources. A review of research on gamification of learning showed that a majority of studies found positive effects from gamification (Sailer & Homner, 2020). However, individual and contextual differences exist. For example, Yildirim (2017) reported the positive impact of gamification on student achievement and attitude in mathematics teacher training process. Kim et al. (2018) reported the promising association of gamification with behavioural economics, but a lack of clarity around what is being learned in the game, development of tools to measure learning in games, and potentially how to better facilitate and replicate learning in games. This is thought provoking from a constructivist viewpoint (Biggs, 1987). The game becomes a vehicle for learning, and emulates aspects of the classroom learning experience as denoted in Biggs' (1987) 3P model of classroom learning. The learning outcome needs to be very clear and it needs to be closely associated with the desired game mission or goal. It follows that if the student learns to succeed at the game then they also successfully reach the learning outcomes relating to the underlying concept. This is the essence of constructive alignment (Biggs & Tang, 2011) applied to gamified learning experiences.

As a potential subsection of the applications of gamification, accounting and finance education is yet to be realised. Observation of accounting professional practice reveals that the role of an accountant has changed (https://www.charteredaccountantsanz.com/; de Villiers, 2010). It is no longer transactional, but a business service. Accountants in the digital age are more accurately described as the providers of a suite of business services, rather than being merely recorders of transactions (Webb, 2020). It follows that the way learners are educated and inducted into the discipline of accounting and finance might also benefit from change (Pincus et al, 2017).

Originally described as the 'Net Generation (Skiba & Barton, 2006) and digital natives (Kennedy et al., 2009), with their preferences for digital delivery, experiential learning, interactivity, and immediacy, students of today challenge faculty to adapt current teaching strategies to accommodate their learning needs (Kennedy et al., 2009; Skiba & Barton, 2006). At the same time educators must ensure the student are equipped with the requisite knowledge and understanding of fundamental concepts and key curriculum. More recently the term digital natives has been contested (Judd, 2018; Smith et al., 2020) in favour of a discussion of digital literacies and "the importance of learning to effectively use technologies as an ongoing process [concerned with] ways to align technological affordances with pedagogy, and through this, the development of learner competencies" (Smith et al., 2020, p. 3-4). Today digital learners (and teachers) inhabit a digital age, immersed in technology (Barcan, 2016) for all their interactions with content and learning. They have "access to affordable multifunctional devices … that readily support their interpersonal communication needs and multitasking behaviors" (Hartman et al., 2005, pp.6.3-6.4)

Regularly scheduled face-to-face delivery of course content for instruction and exams at university is viewed as out-dated and incongruous with the reported learning preferences of new generations (Kennedy et al., 2009; Judd, 2018).

Recent research highlights that emerging technologies can improve student learning processes, outcomes, and assessment practices if managed and aligned with pedagogical, technical, and administrative issues (Kennedy et al., 2009; Smith et al., 2020). The trend in education is towards fully online learning. This trend has accelerated with the COVID-19 pandemic (e.g., Adedoyin & Soykan, 2020; Liguori & Winkler, 2020), raising the relevance and significance of this research to learning and teaching in a post-COVID world. Disruptions aside, online learning is preferable to many students as it accommodates the differing levels of time, effort, and interaction required to absorb new content, reflect, and self-assess (Human et al., 2005). Earlier studies, when access to the internet for education was quite new, showed that online learning could improve retention and had no negative impact on outcomes when measured by grade distributions (Cantoni et al., 2004; Human et al., 2005; Neuhauser, 2002; Tata, 1999). This was probably because there was very little difference between traditional learning and teaching during this time. Not all students had computers at home. Nobody had a mobile device (Hartman et al., 2005). Online content was accessed for learning in computer labs on campuses. Conversely, in later studies, when students have smart devices, content is accessible via the university learning management system (LMS) by logging in remotely, and they can choose to isolate, show that many students have trouble staying motivated and engaged with online learning experiences (Greenland & Moore, 2014; Moore & Greenland, 2017), and that this varies according to unit level. Li and Wong (2019) identified institutional factors of effective learning design and delivery as creating the biggest impact on student persistence and ultimate success. Walsh et al. (2020) stated that it is the online cohort that experiences the highest level of attrition, and "many universities struggle to successfully deliver online postgraduate education as measured by students' satisfaction, academic success, continuation, completion, and transition rates" (p. 30-31). This is probably more to do with the lack of understanding of how to build and maintain learning experiences in the online realm (Li & Wong, 2019). That is, many academics have a lack of technological, pedagogical, content knowledge (TPCK) (Koehler & Mishra, 2005) and are therefore resistant to change.

(Barcan, 2016). Koehler and Mishra (2005) investigated, "What happens when teachers design educational technology?" They concluded that:

> Good teaching is not simply adding technology to the existing teaching and content domain. Rather, the introduction of technology causes the representation of new concepts and requires developing a sensitivity to the dynamic, transactional relationship between all three components [technological, pedagogical, content knowledge] suggested by the TPCK framework. (p. 134)

Allain (2020) confirms and extends this, stating that when teaching online, solely transferring the conventional lesson plans used in the classroom to the online learning environment is not the answer. Learners interact with material differently when online compared to face-to-face. Activities that "work in the classroom typically cannot directly transfer to online, nor do online activities conveniently adapt to conventional classroom delivery" (Tennant et al., 2010, p. 132). A blended learning environment, defined as any learning environment on a continuum between online learning and face-to-face learning, incorporates elements of both (McKenzie & Parker, 2011).

1.4 Synthesis of a gamified curriculum and threshold concepts

The structure and mechanisms of gamification provide a template for learning designers to integrate and implement threshold concepts. de Villiers (2010, p. 10) asserted that although "content knowledge becomes dated and is not transferable", threshold concepts not only do not become obsolete, but are the critical underpinnings of understanding "across [courses] and careers". She further advised that to "remain relevant", curriculum developers need to find "innovative ways" to include problem solving, time management, effective communication, and working in groups (de Villiers, 2010, p. 10) in their cache of pedagogical resources for delivering content. The challenges are limited financial, human and physical resources (Carr & Cameron-Rogers, 2016;

Laurillard et al., 2013), rewards, remuneration requiring the problematic paradigm shift from research centred to teaching and curriculum development, and the challenge of ensuring technology used for education, not just providing entertainment. Given the constant exposure to infinite volumes of information, and the expectation of instant access, de Villiers (2010, p. 13) posed the question of how to redesign "instructional techniques to cater for the highly visual, over-stimulated learners".

Many changes in learning management systems and standards for online learning have emerged since de Villiers' (2010) paper. Quality Matters (https://www.qualitymatters.org) and related frameworks for the design and evaluation of online learning materials and sites have been widely adopted by universities, each of which have created their own blended learning models to provide guidance in the features and structure of online learning with high-impact learning experiences. Czerlawski and Lyman (2016) proposed an instructional design framework for developing good design while for fostering student engagement in online learning. Further, Holland (2019), in a meta synthesis study, identified two effective principles of informal online learning design: (1) knowledge construction supported by opportunities for interaction, and (2) educational activities presented in small content segments. The important outcome is that student experiences and technology use are better aligned, ultimately leading to opportunities for improved learning outcomes.

Formative assessment via "continuous activity with immediate feedback" (Sancho-Vinuesa et al., 2013, p. 1) throughout the life cycle of a gamified learning experience provides such learning opportunities. The learning and game goals are set in the learning design. To achieve that goal requires the learner to use a mix of self-determination and gameplay options. The intermediate steps that are self-determined by the learner shape the gamified learning experience until the goal for the game and learning is reached. Formative assessment encourages student self-assessment in "a three-step process in which students judge their own work (self-monitor), identify discrepancies between current and desired performance (self-evaluation), and identify and implement further learning activities to enhance their understanding or skills" (Cauley & McMillan, 2010, pp. 5-6). Formative teacher assessment (Sadler 1989, 1998) in the gamified learning experience occurs where the teacher has engaged with learner progress in the design, by way of feedback options that are planned based on possible learning progress markers and errors. Teacher assessment allows for remedial action for learners. It can take the form of presentations, discussions, and feedback, and aids in facilitating the development of higher order thinking skills (Gikandi et al., 2011; McCarthy, 2017). Immersive story lines in gamified learning provide authentic learning and assessment opportunities with variables not always in the control of the teacher. The teacher acts as the *boundary rider*, that is, they define the parameters of the learning space (Thomas & Seely Brown, 2011) and provide formative assessment during the learning game.

Although we see many examples where technology as a key driver for change has been included in learning and teaching – interactive courseware, virtual classrooms, discussion boards, computerised examinations (de Villiers, 2010) – this is not curricula. Technology provides the medium to employ pedagogy and deliver the curricula. To fully embrace a gamified curriculum requires utilisation of tools that many students use in daily life. Learning is a social enterprise (Vygotsky, 1978), and social networking is a daily social enterprise of many learners. Using such a social network as a medium, applied to the learning in a gamified curriculum has been found to positively impact learner ability to form socially constructed knowledge with other learners and contribute to new avenues of learning in first year ICT students (de-Marcos et al., 2016) and foreign language students (Donmus, 2010). In the connectivism philosophy of learning (Bell, 2020), knowledge is distributed across a network of connections between learners and information. "Technology can and should be used to promote the active development of knowledge and understanding and not to cement it as a static object" (Millwood & Terrell, 2005, p. 200).

1.5 Research questions

From this synthesis of a gamified curriculum and threshold concepts, the central controlling questions of this research were distilled.

1. How can a gamified learning experience enhance **student engagement** in learning about technical threshold concepts of accounting and finance?
2. How can a gamified learning experience enhance **student learning outcomes** in technical threshold concepts of accounting and finance?
3. How can the enactment of the principles and framework of gamification in the delivery of technical threshold concepts in accounting and finance enhance **student self-efficacy**?
4. How can the enactment of the principles and framework of gamification contribute to the **learning design** for the teaching of technical threshold concepts in accounting and finance?

1.6 Rationale of the research

Critical thinking has been identified as a desirable attribute for graduates by the Australian professional accounting registration bodies. Both CPA Australia and CAANZ require graduates to be able to demonstrate technical competencies threshold concept knowledge and the critical thinking skills to apply this knowledge. In order to develop these skills, higher education needs to reflect the role of accounting and finance professionals in the learning opportunities and resources provided in the curriculum (Hancock et al., 2016).

Referring to the accounting profession, Mathews (2010, p. 118) observed that “changes in the business environment [are driven by] technology, globilisation, and concentration of power”, all of which focus “importance on the use of information” not just the traditional financial statement, basic accounting and taxation aspects of accounting. Information processing and finance decision making skills are ubiquitous in higher education providers’ lists of graduate attributes. Traditional pedagogy in accounting – “a pre-technology education context where the teacher is the sender or the source, the educational material is the information or the message, and the student is the receiver of the information" (Mbodila & Muhandji, 2012, p. 1) – with its concentration of theory and content, does not embrace technology and the activity of constructivist learning theory. This leaves accounting and finance students isolated from other parts of business theory where analysis, evaluation, and higher order thinking skills are critical. Not only is there a need for "breadth in accounting education" (Mathews, 2010, p. 121), but a revision of pedagogy with a reform of curriculum.

1.7 Research Design

The application of social constructivism and cognitive load theory, employing sequential mixed methods, was used to examine and inform the design of this research. Social constructivism provided a philosophical approach and stance about how learning happens and underpinned the research design. Cognitive load theory contributed to the design of effective learning experiences for students. Through the observation of the learners' interface with the GLE, the collection of statistical quantitative results from the sample, and the use of qualitative data to seek to explain the relationship between variables, the research explored how the GLE was experienced, and explained the results.

To explore the experience, motivation, engagement, and learning outcomes of the experimental GLE, participants were recruited from among undergraduate and post graduate accounting and finance, business students at Southern Cross University, and randomly assigned to either a control group or treatment group. Both groups completed a self-report demographic survey and a learning styles index survey, which included the collection of information about their interest and experience in the subject, their perceived expectations, use, and benefits of e-learning games (Koivisto & Hamari, 2014), plus certain learning environments and the preferences learners have for learning using visual, auditory, or kinaesthetic means (de Byl, 2010). This qualitative data was used to improve the robustness of the quantitative survey data, game log data, and measured assessment learning outcomes of the experiment (Kapp, 2012). Higher order thinking skills of "Analyse" and "Evaluate" (Bloom, 1956) were required in the activities in the GLE where students applied earlier learned knowledge to new scenarios and had to evaluate and make choices between various outcomes. The GLE also engaged higher order thinking skills in the learning outcomes assessment test, which was the final game level. The combination of qualitative and quantitative methods is commonly used "to measure against, and find corresponding learning in, results and pattern or path, number of transactions/decisions time, and game mechanics" (Hamari et al., 2015, p. 177).

1.8 Contributions

This research was designed to evaluate the effectiveness of a gamified curriculum and pedagogy for delivery of a technical threshold concept, TVM, a key component of accounting and finance education. The researcher developed, contrasted, and evaluated the effectiveness of a gamified curriculum using a blended teaching and learning delivery method. The research: (1) evaluated the effectiveness of a gamified learning experience pedagogy for one complex technical threshold concept, TVM, in accounting and finance; (2) provided a tested model for gamified learning that could be potentially applied to other threshold concepts, and (3) developed and disseminated an evidence-based framework and survey for learning design development in these disciplines. The research questions were examined to look at the need for higher education providers to utilise available and emerging technologies to deliver relevant, engaging, and motivating threshold concept content to current and future learners.

Specifically, the contributions of this research are:

1. A **guided, descriptive literature review** which indicates a clear understanding of the current knowledge of the areas of threshold concepts in accounting and finance, learning design, and gamification of learning, including the overlapping areas. The literature review also indicates the gaps in current knowledge and provides a clear indication of where further work is needed: gamification of financial accounting education, in

particular the gamification of technical threshold concepts, and gamification of the time value of money concept.

2. A novel mapping of pedagogical and gaming terminologies in a **gamification alignment table,** “a comprehensive and common vocabulary for describing game-based learning concepts and design features” (Lameras et al., 2015, p. 19), to assist educators and designers to constructively align and assess student learning and within a GLE.
3. A **gamification alignment model** to assist learning designers and teachers to match the types of games to deliver different gamified learning experiences.
4. The application of a **generalised conversational framework** (Laurillard, 2002) for evaluation of gamified learning experiences, showing constructivist, social constructivist, and cognitive learning theories at its core.
5. A **new eLearning game** for TVM, created for this research and tested for its efficacy, and refined based on user testing.
6. A revised eGameFlow survey – **eLearningGameFlow** – used in the research, to focus on, and more precisely test, the student experience of learning within a game, not just the features of a GLE that assist the student.

In addition, and given that the hypotheses were derived from an extensive review of the literature that suggested there should be some significant influence of gamified learning then, the non-significant findings of engagement with learning and performance will contribute significantly to the knowledge of GLE design, directing future research attention to the design of the interaction points of the student experience of learning within the GLE. The finding of a significant relationship between self-efficacy and the technical threshold concept of TVM from the empirical testing analysis extends the current knowledge of self-efficacy as a determinant of learning by including the use of learning games to support successful learning outcomes.

1.9 Structure of thesis

This thesis adopts the following structure. Chapter 2, Literature Review, examines the three areas of research: (1) gamification of learning; (2) learning design for student engagement; and (3) threshold concepts, and describes the parallel theories and links between and amongst them. Chapter 3, Theoretical Framework and Methodology, maps the lexicon of pedagogy to gamification in a gamification alignment table and a descriptive gamification alignment model. It develops the research theoretical framework within which the hypotheses are investigated. Chapter 4, Method, provides an overview of the choice of research methods and instruments employed for data collection, measurement of key variables, and data analysis. The implementation of the GLE experiment is described, followed by the collection and validation of data, and the sample description. Chapter 5, Results and Analysis, examines the results and analysis of data gathered from the qualitative and quantitative methods; learner questionnaire, learning outcomes, survey, follow up interviews, and discussion board. Chapter 6, Discussion, looks at the research participants reported demographics and learning preferences. Then using the multivariate ANOVA interpretation from the analysis chapter, this chapter examines the correlations to learning experience and outcome results and make inferences about learner engagement, learning success, and self-efficacy. The contributions and limitations of the research are described. Chapter 7, Conclusion, summarises the overall objective and outcomes of the research, acknowledges the inhibitors, and give indications for future research. Appendix 1, Experimental Design, contains the researchers experience of, and reflection on, developing the experiment treatment gamified learning experience for the time value of money.

1.10 Summary

This chapter has introduced the research into the gamification of curriculum to be applied to time value of money, a technical threshold concept in accounting and finance. The context of liminality and the role of a gamified curriculum to deliver adaptive, engaging content that transforms learning were identified.

The motivation for the research was identified as the alignment of student experience with technology use and the contemporaneous harnessing of digital resources in learning design for delivery and understanding of fundamentals. The following chapter, Chapter 2: Literature Review, will examine the three areas of literature for this research: (1) gamification of learning; (2) learning design for student engagement; and (3) threshold concepts, with the subtopic of accounting and finance technical threshold concepts.

Chapter 2 – Literature Review

2.1 Introduction

Chapter 1 introduced the gamification of curriculum to be applied to time value of money, a technical threshold concept in accounting and finance. It established the context of liminality and the role of a gamified curriculum to deliver adaptive, engaging content that transforms learning. Motivated by the changing expectations of learner cohorts and the contemporaneous harnessing of digital resources to deliver knowledge and understanding of fundamentals, the research aim and the objectives for the study were developed. This chapter uses a descriptive, narrative literature review guided by the research questions to explore the three areas of literature for this research: (1) gamification of learning; (2) learning design for student engagement; and (3) threshold concepts, with the sub topic of accounting and finance technical threshold concepts. Literature was sourced through the Google Scholar database to provide a breadth of data sources. Gaps in the literature relating to this research are revealed.

2.2 Three areas in the literature

For the most part, the body of existing research on gamification in educational settings still compares traditional pedagogy to gamification pedagogy (Acosta-Medina et al., 2021; Kapp, 2016; Kim & Ifenthaler, 2019). Although obfuscated by problematic implementation (Carr & Cameron-Rogers, 2016; Kim et al., 2018; Moncada & Mondada, 2014), there is general consensus that gamification has a positive effect on learning outcomes and engagement (Sailor & Homner, 2020), and points to the next level of investigation, that is: what gamification features lead to learning, and when; the conditions which support gamification for learning (Kapp, 2016); and how to integrate the conditions to ensure learning outcomes are met (Kim & Ifenthaler, 2019). This literature review takes a defining approach, examining the extant literature in three areas of research: (1) gamification of learning; (2) learning design for student engagement; and (3) threshold concepts and their representation in accounting and finance. Figure 1 provides a visual structure for the scope and selection of literature for qualitative review and how they fit together.

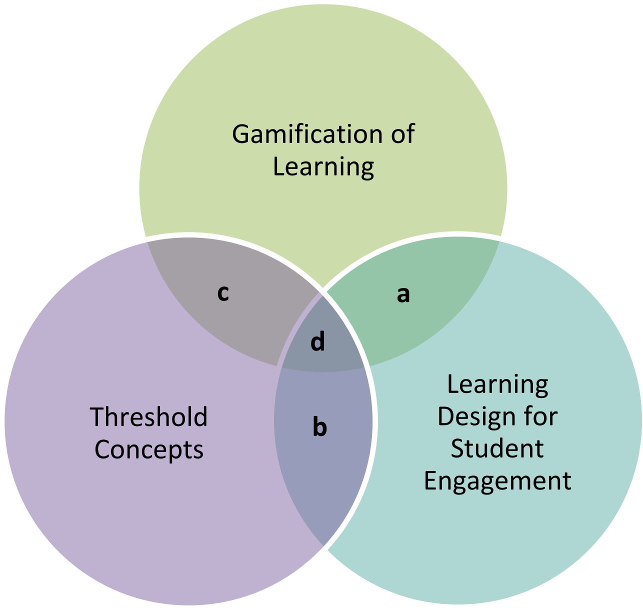


Figure 1 **The three areas of the literature review showing their interactions**

Note. Intersections:

(a) Learning design for student engagement using gamified learning
(b) Learning design for student engagement in threshold concepts in accounting and finance
(c) Gamification of learning for threshold concepts in accounting and finance
(d) Learning design for student engagement using gamification of learning for threshold concepts in accounting and finance

The three areas are not unrelated, and conversation about one area necessitates talking about the commonalities, the links, and the junctures with the others. These are shown as the intersections in Figure 1. With the consideration of the gamified learning experience (GLE) as a lens to impact and inform this research, theories that are present in each of the areas are elucidated and discussed, and links between and amongst the three areas are described. The landscape of research and literature about accounting education and learning resources in higher education, was methodically searched using the Google Scholar database to identify and define the areas of investigation that the descriptive narrative of the literature review (Xiao & Watson, 2019) would cover. After the initial search of literature an iterative process identified subtopics within each main topic. The three areas of investigation are outlined below.

Gamification of learning

The development of the gamification of learning section of the literature review discusses the fundamental elements of the learning game. These are in two groups. First are the structural components and mechanics (Fabricatore, 2007). Second are the content components of theme, design, learner characteristics, and plot driven narrative (Hendrikx et al., 2013). The plot driven narrative is the story line with emphasis on the plot, which is the track the learner follows through the content (Bopp, 2007). This section then describes how flow theory can be applied to games (Csikszentmihalyi, 1990), to turn gamification into a learning game.

Learning design for student engagement

The learning design section of the review includes curriculum (what is to be learned) and pedagogy (how learning is supported or guided). This section of begins with the learning design features that lead to learning and support gamification, engagement and motivation, and active learning. In addition to these learning design areas, the search was expanded to include gamification and game-based learning in accounting and finance and other disciplines. This identified what is already known about: gamification in accounting education; the emergent literature on experiential learning (Kolb, 2014); self-directed learning (Goffman, 1961; Juul, 2005; Koster et al., 2004); adaptive learning (Brusilovsky & Peylo, 2003) and the traits and characteristics of learners (de Byl, 2010; Felder & Silverman, 1988, Solflano et al., 2015). Learning taxonomies are discussed, leading to an exploration of education technology and the digital learning environment, and the place and role of formative and game-based assessment.

Threshold concepts

This section starts with a general definition of threshold concepts, and is then refined to the threshold concepts in accounting and finance, before identifying the technical threshold concept of time value of money (TVM) (Dempsey, 2003) used in this research. The two established methods of teaching TVM, through tables and formulae, are critiqued in terms of cognitive load theory (Sweller & Chandler, 1991; van Merrienboer & Sweller, 2005) and authentic learning (Herrington et al., 2003) to determine if these current pedagogies are well-matched to digital learners. In this examination of the teaching accounting and finance technical threshold concepts, research on current pedagogy and learning design, revealed the following themes of discussion: work integrated learning via the inclusion of authentic technology in the curriculum, due to external pressure from professional accrediting bodies and employers; the curriculum as a reflection of available technology; and the pedagogical underpinnings for the use of technologies.

This chapter is structured as follows: the first two areas of research, Section 2.3: Gamification of learning, and Section 2.4: Learning design for student engagement; followed by their intersection, Section 2.5: Learning design for student engagement using gamified learning (Figure 1, intersection a); the third area of research, Section 2.6: Threshold concepts; followed by its intersections with the first two areas, Section 2.7: Learning design for student engagement in threshold concepts in accounting and finance (Figure 1, intersection b) and Section 2.8: Gamification of learning for threshold concepts in accounting and finance (Figure 1, intersection c); and finally the intersection of all three research areas, Section 2.9: Learning design for student engagement using gamification of learning for threshold concepts in accounting and finance (Figure 1, intersection d).

2.3 Gamification of learning

The term gamification captures the idea that “certain elements of games can be infused into instructional situations to provide a positive learning outcome without having to create a full-blown learning game" (Kapp, 2012, p. 137). Extending this, instructional gamification commonly applies game-design elements and game principles (the mechanics and tools) in non-game contexts (Deterding et al., 2011; Huotari & Hamari, 2012) (i.e., curriculum and learning activities) in attempts to improve user engagement with learning (Appleton et al., 2008; Shulman, 2002), student outcomes (Sadler 19689, 1998), flow (Csikszentmihalyi, 1990), motivation (Ryan & Deci, 2000; Schoenau-Fogg, 2011), self-directed learning (Goffman, 1961; Juul, 2005), and ease of use and usefulness (Davis, 1989) of learning resources. This definition has evolved into two aspects of gamification: structural and content. With structural application of game elements "the content does not become game-like, only the structure around the content does" (Kapp, 2012, p 137). An example of this is the introduction of scoring elements. Content gamification is the addition of narrative to engage learners.

First known as *serious games* (Djaouti et al., 2011), researchers and designers have now opted for the preferred term of gamification (Walz, 2015; Zichermann & Cunningham, 2011): *serious* and *games* together being an oxymoron. Games are creative spaces and provide opportunities for imagination and play. When do they become serious? Why does the free play of childhood give way to the more serious pursuit of learning? Does it have to? (Vygotsky, 1978). Do educationalists need to overcome the perception that games are for fun rather than learning? Or is this more in the teachers' perceptions than the students?

A number of researchers have sought to address these questions. Deterding (2012) observed that, rather than being fun, early gamification methods created an artificial sense of achievement. In a critical analysis, Radoff (2011) pointed out the absence of storytelling or narrative to engage learners in gamification. GLEs do not have to be fun (Grund & Meier, 2016), but they do need to contain the elements of games designed for entertainment to produce the environment for flow (Csikszentmihalyi, 1990). This assists in maintaining the balance of challenge and difficulty within context to perpetuate play and propel the learner forward towards the learning objectives. In a workshop setting, Hosseini and Hartt (2015) used the domains of Bloom's (1956) taxonomy of learning to explore the possible relationship between games and learning for application to university learning, and sought to make links between thinking skills and game types.

Further, researchers are reporting on a shift in gamification of learning in the role of the teacher, from a traditional didactic approach to a mediator role, taking into consideration the existing schema and study process of the learners (Damsa, 2016). There is demonstrated by a continuous feedback and evaluation process, the most basic being points and levels (Klopfer et al., 2012). Here the learner focus is on progression through the GLE, information collection, and accumulation of knowledge. This is paralleled in business via benchmarking and key performance indicators, and other activities which monitor and report progress, for example fitness apps and interactive diaries. These feedback systems offer the learner opportunities to "experience their development and progression by using visualisation" (Damsa, 2016, p. 30), thus, reversing the grading focus from a static *bad* mark to a perception of movement to next level (Tapingkae et al., 2020). From the teacher's perspective the availability of transparent, timely information about the progress of individual learners' and whole of cohort progress, offers opportunities for intervention, feedback, clarification, and provision of supplemental material (Boud & Associates, 2010).

This section now provides a summary of key game elements and characteristics required to create a GLE: *mechanics and structure*, *real time decision making*, and *flow*, and the *zone of proximal development*.

2.3.1 Mechanics and structure for a GLE

Game mechanics are tools, techniques, and coded items (Fabricatore, 2007) that are adopted and adapted from game design, to be the building blocks for the gamification of a learning experience. Playing a video game and having a GLE involve the same mechanisms (Damsa, 2016). Both are simple and yet complex systems using points, levels, leader boards, storylines, avatars, and group activities.

Fundamental to the GLE, learners have access to specific combinations of the mechanics, objects, and tools that comprise the structure of the game (Fabricatore, 2007). To satisfy learners' progress as the game becomes more complex, we see customisation, quests, and social engagement loops (de Byl, 2013). These techniques work together creating choice, increasing challenges, and adaptive story lines to make learning activities feel like games. However, complexity in game mechanics does not inevitably equate to engagement or demonstration of learning. It is only desirable that the game mechanics allow for learners in a GLE to have an engaging, but not necessarily fun, experience (Sicart, 2008). The complexity of the various game mechanics determines the level of player interaction with the game environment and its resources.

Learners can demonstrate achievement of learning objectives (Sadler, 1989, 1998) and construct new challenges for themselves using those same elements (Juul, 2005; Sweetser & Wyeth, 2005). This construction of additional goals or setting of rules and parameters outside of the original intention of (Hooper, 2013), but not restricted by, the education designer is characteristic of creativity through play as discussed by Vygotsky (1978).

Game structure delineates the possibilities for action in the GLE. It is the bounded arena in which the learning activity can take place (Thomas & Seely Brown, 2011). The structure of a GLE can be: (a) physical, in the curriculum described by a concept map showing levels of learning, and the available game mechanics (Fabricatore, 2007), the rules that shape the experience; or (b) narratological, that is, the story and character determined in-game events (Hendrikx et al., 2013) which affect perception of the game and learner agency to progress towards the end goal.

The building of a GLE requires significant investment in the design stage to apply game mechanics and structure (Carr & Cameron-Rogers, 2016; Moncada & Moncada, 2014), at the same time allowing for a range of learner preferences and potential motivators (Soflano et al., 2015). This attendance to front end composition ultimately determines the success of the GLE (Laurillard et al., 2013). As Kruse (2002) stated when discussing "the benefits and drawbacks of e-learning, … situat[ing] learners in authentic environments [has] more challenging aspects, [and is] not just the easiest to implement" (p. xii).

2.3.2 Real-time decision making

Research in the areas of business intelligence and analytics by Grund and Meier (2016) investigated the use of games for experiential learning and found the capabilities and skills necessary in the decision-making process could viably be learned and enhanced by playing serious games. The 5-phase decision process for organisations (Grund & Meier, 2016), including the iterative stages of intelligence, design, choice, implementation, and learning, is applicable to the acquisition of accounting and finance technical threshold concept competencies. Serious games constructively aligned (Biggs, 1987, 2003) as experiential learning (Kolb, 2012) can be effective for increasing knowledge and skills (Lin et al., 2013) because they provide learners with opportunities to experience the challenges of a real work world environment. For example, there are business games where players (learners) compete as office holders of simulated companies in a virtual marketplace (Faria et al., 2009), supported by the development of people centric (or soft skill) decision making skills.

2.3.3 Flow

The game elements and characteristics used to inculcate flow in games have been extensively researched. Drawing from psychology, Csikszentmihalyi (1990) described this concept of *flow* as the optimal mental state where a person is completely occupied with a task that matches their skills: where the activity is neither too difficult nor too simple. Being *in* flow then is to experience complete absorption and engagement with a physically and/or cognitively stimulating activity (Csikszentmihalyi, 1990). This provides the opportunities to question and develop own understandings (Simon, 2016) and in turn fosters feelings of confidence, enjoyment, and satisfaction (Csikszentmihalyi, 1990). In fact, "the best moments in our lives are not the passive, receptive, relaxing times. The best moments usually occur if a person's body or mind is stretched to its limits in a voluntary effort to accomplish something difficult and worthwhile" (Csikszentmihalyi, 1990, p. 3).

Csikszentmihalyi (1990) identified seven indicators in his model of flow:

- engagement in an activity that requires a high level of skill and is sufficiently challenging but retains the possibility of success,
- the activity becomes central to focus and instinctive,
- goals are clear and there is immediate feedback,
- concentration on the activity precludes awareness of anything else,
- control or governance over the activity while simultaneously accepting and embracing the possibility of losing control,
- loss of self-consciousness or self-awareness as immersion increases, and
- the transformation and lack of perception of the passage of real time during the activity passing more quickly whilst fully immersed in an activity.

This flow model is seen as the optimum pairing of skill and challenge, although not all indicators need to be present for flow to be achieved. Csikszentmihalyi (1990) further identified other emotions and mental states that may be entered into depending on the *imbalance* of skill and challenge within the activities:

- apathy, when the challenge of the activity is perceived as far too simple and requires minimal skill on part of the participant,
- relaxation, where the activity is not challenging but the outcome is desirable so the participant remains partially engaged,
- boredom, where although an individual may require a moderate level of skill to complete an activity, there still exists little if any challenge,

- worry, when engaged in an activity that offers a moderate level of challenge, but the participant lacks the required skills to demonstrate competence or complete the activity, and
- anxiety, where the participant does not have the required skills to complete a complex challenge.

Figure 2 is a graphical representation of the flow channel, the place where the game player/learner "experiences the flow state continuously while both skill and difficulty gradually increase" (Redd, 2012). The flow path (blue line) is not a regression line plotted against the two axes of challenge and skill, but a line representing learner movement of experiences between easier wins and greater challenges, which don't extent to inducing either boredom or anxiety.

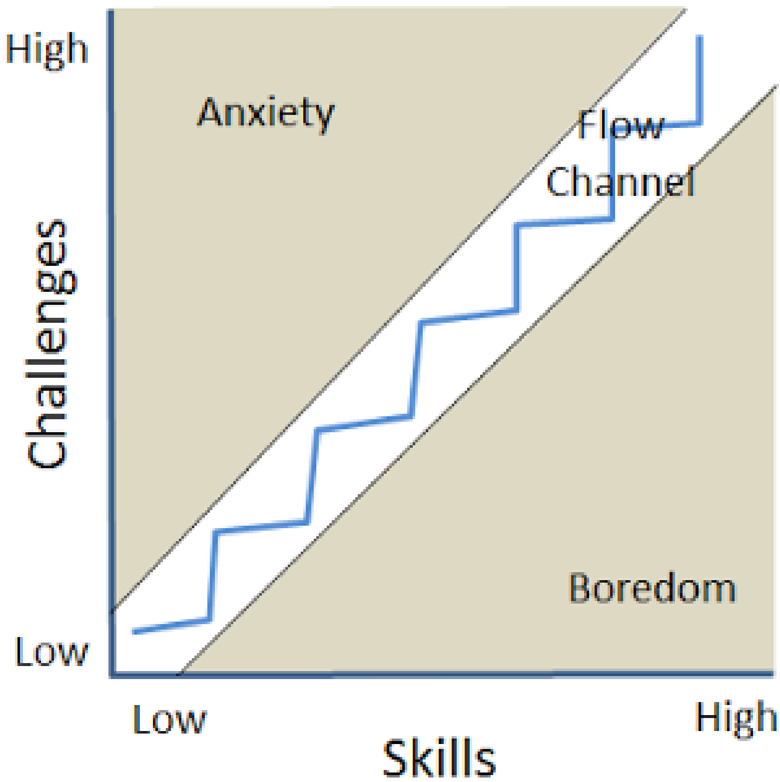


Figure 2 The Flow Channel (Csikszentmihalyi, 1990; Redd, 2012)

Although adopted to describe the immersive play in videogames where players become engaged with the game through the pursuit of artefacts, the completion of quests, the allure of the narrative of the game, and elicited emotional responses, flow theory (Csikszentmihalyi, 1990, 1996, 2008) provides a model for discussion of GLEs. It illustrates how a well-designed game can propel the game player (our learner) deeper into the game (the content) on a voyage of discovery and learning, such that time spent in the mental state of flow is positively correlated to the activity of learning. In education literature a similar phenomenon of scaffolding exists where educators control the difficulty level of content and learning activities being provided to students in order to keep them engaged (Chen & Law, 2016; Vygotsky, 1978; Vygotsky et al., 2012). This is also the case with algorithmic adaptive learning (Ghosh et al., 2020). Play literature from the field of psychology draws parallels between curiosity and learning (Kuczaj, 1985; Pepler & Ross, 1981; Piaget, 1951). Vygotsky (1978) suggested that the imaginary situations and rules implemented by children at play contributed to cognitive development. Although from different disciplines, each of these researchers is describing flow theory, and how it works to engage students and advance learning.

2.3.4 Zone of proximal development

Vygotsky (1978) held that, when learners are supported in their search for and accumulation of knowledge, not merely directed by a teacher with a summative assessment focus, development was spontaneous. Following cognitive researchers describe this process as scaffolding the learning activity (Chen & Law, 2016; Sharma & Hannafin, 2007) to assist the learner to gain new levels of understanding, by building knowledge and capacity with more complex information and progressively harder challenges (Lucas & Mladenovic, 2009). Defined as the zone of proximal development (Berk & Winsler, 1995; Vygotsky, 1978), it is the threshold where the learner is not yet competent and able to complete a task independently; that is, the place where learning occurs.

With a slight change of labelling, Redd (2012), in Figure 3 restated the flow channel as the zone of proximal development: the space where the learner can achieve with assistance. Boredom is described as what the learner can achieve independently, and anxiety as what the learner is not yet able to achieve.

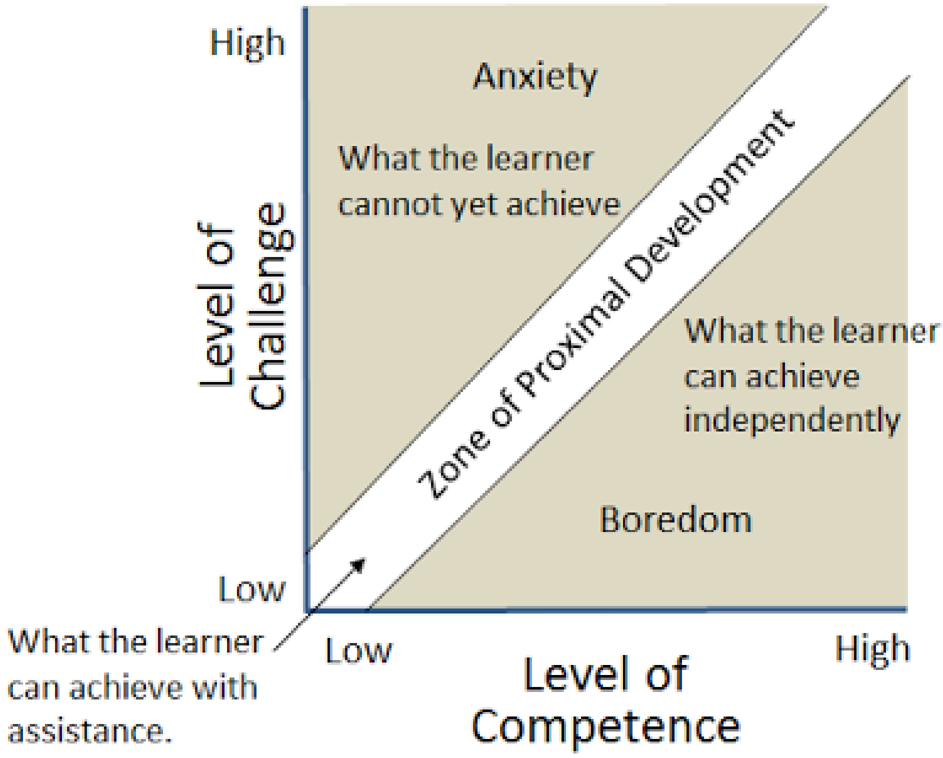


Figure 3 **Zone of Proximal Development (Redd, 2012)**

This section has reviewed the research of key game elements and characteristics required for gamification of learning, that is, mechanics and structure, real time decision making, and flow, and the zone of proximal development.

2.4 Learning design for student engagement

In research on learning design for student engagement, Arnab et al. (2013) held that one of the most common challenges for learning games is the test of being pedagogically sound. As Kapp (2016) identified, much of the research compares traditional pedagogy to gamification. He posits that we should be asking the questions: (1) What features lead to learning, and when; (2) What conditions support gamification; and (3) How can they be integrated to ensure learning outcomes are met? Taking his lead and in an attempt to contribute to filling this gap, this research links the pedagogy of the learning game to learning design.

The pivotal feature of the link is that the gaming world, and by design the learning game, is always forward focused, evoking "curiosity about the final outcome of the storyline [and] the future destiny of the … characters" (Bopp, 2007, p. 256). Feedback and formative assessment is always framed in terms of progress towards the next goal or learning outcome (Tapingkae et al., 2020), never as a static result or point in time. Games work as motivators in an educational setting because they are accumulative not degrading (Chen, 2017): points are always achieved towards a total, not removed from a possible total. For example, World of Goo is fun physics-based puzzle/construction game meant for school age learners: "The millions of Goo Balls who live in the beautiful World of Goo don't know that they are in a game, or that they are extremely delicious" (https://2dboy.com/). In one scenario, learners are challenged to find their way out of a creature's stomach, by first accumulating enough points from exploring and learning, to create a raft on the sea of his digestive juices.

The term *gamified learning experience* (GLE) used in this research, encompasses both the gamified structure around the content and the plot driven narrative – the story that illustrates and carries the content – to describe the pedagogical practice of using gamification for learning. Various researchers writing about the relationship between GLEs, learners, and teachers, report a growing interest in the pedagogy of a GLE (Egenfeldt-Nielsen et al., 2008; Marklund & Taylor, 2016) recognising "potential and intrinsic educational value but little integration" (Marklund & Taylor, 2016, p. 122). Elsewhere the emphasis has been on game artefacts and the relationship of the learner with the game to measure "viability and efficacy of games as learning resources" (p. 122).

While, from an epistemological perspective, researchers (Kapp, 2012, 2016; Marklund & Taylor, 2016) claim high potential and positive correlation between gaming and learning, there remains a paucity of empirically grounded literature exploring games as teaching tools in formal learning settings; that is, within the constraints of a designed curriculum with teacher supplied resources, to enable measurement and replication. However, "using [only] the fulfilment of pre-defined learning objectives as an effectiveness parameter does not allow developers and researchers to see unexpected and unintended changes in practice that occur as a result of the eLearning program" (Noesgaard & Orngreen, 2015, p. 278). To gain a broader understanding of the value of GLEs, the quality of the pedagogical structure and components, as well as the quality of their artefacts or activities, in the learning design need to be studied (Eklund, 2012).

The following sections describe the aspects of learning design and how they relate to the GLE.

2.4.1 Learning design features that lead to learning and support gamification

2.4.1.1 Engagement

Student engagement, and specifically engagement for learning, is an extensive body of research. Within the field, Appleton et al. (2008) divide learner engagement into three categories:

1. Cognitive engagement, where students' desire to learn beyond session content through additional challenges sees them invest additional time to achieve deep understanding;
2. Behavioural engagement, where students' attention and persistence is in flow, not characterised by incidents of disruption; and
3. Emotional engagement or willingness to engage with content and activities.

However, Appleton et al. (2008) make engagement a learner-centred concept, talking about learners as if they are all "Susans", to use Biggs and Tang (2007) term for students who are deep learners and already engaged with learning. In reality there is a huge proportion of "Roberts", those who are less engaged and surface learners (Biggs & Tang, 1999), and it is for them that the GLE will be perhaps most useful for learning as it is developed to encourage cognitive engagement, behavioural engagement, and perhaps some emotional engagement (Appleton et al., 2008) after rewarding experiences of success with learning. Here, engagement is described for each student individually, and in comparison to their previous or usual engagement with learning, and their cognitive engagement, like behavioural, is characterised by their persistence in exploring the concepts portrayed in the game content.

Complementing Appleton et al. (2008), for Shulman (2002), engagement is a necessary precursor for learning. A student must engage with something. They can engage with: (1) the university learning systems, (2) university learning community, (3) the process of learning, (4) the objects of learning, (5) the relationships between concepts and knowledge constructs, and (6) the implications of learning beyond assessment and to society and community.

Further research has investigated engagement in technology enhanced learning. In digital storytelling, engagement is the product of the user's investment of time and energy that then affords the interactive experience (Schoenau-Fog, 2011). Whereas the concept of fun is a by-product of an engaging game experience (Goffman, 1961), this same aspect of fun may be experienced by learners in a GLE in terms of satisfaction of problem solving (Juul, 2005) and the understanding of the process or pattern of the GLE (Koster et al., 2004). Schoenau-Fog (2011) identified four factors for videogame engagement: *objectives*, *activities*, *accomplishments*, and *affect*, which can be applied to the GLE.

1. *Objectives* in a videogame equate to learning objectives (Sadler, 1989, 1998), and are extrinsically defined by the curriculum, or may be self-directed learning objectives (Goffman, 1961; Juul, 2005; Koster et al., 2004) intrinsically set by the student.
2. *Activities* are the learning activities the student must engage in for the purposes of attaining the set objectives (Hamari et al., 2015). In these

activities the student uses the gamified learning mechanics to solve problems, test hypotheses, explore, create and critically analyse new information and ideas, and socialise with non-player characters or other students in the gamified environment.

3. Fulfilled learning objectives are the *accomplishments* or successfully completed assessment tasks (Moore, 1989). Students are rewarded for accomplishments not only by achievements (Mason et al., 2016) or grades awarded in the GLE, but also through formative feedback (Sancho-Vinuesa et al., 2013) and the sense of accomplishment in progress through the gamified learning content and increasing levels of knowledge.

4. *Affect* for engagement is the measure of success the gamified learning components have on the student in either keeping them engaged through satisfying content and progress opportunities: that is whether they *like* the experience. This is quantified through the measurement of learning outcomes combined with a satisfying experience. It is, however, important to also recognise that a negative affect can also result if students become bored with, and disengage from, the gamified learning experience (Schoenau-Fog, 2011).

Hamari et al. (2015) included challenge with skill as the components to achieve *flow*, that is, complete absorption and enjoyment, and investigated how flow, engagement, and immersion combined to influence learning in a GLE. They found that challenge and engagement had positive effects on learning, and, while there was no significant effect from immersion, challenge and engagement together led to immersion, and were strong predictors of learning outcome success. Hamari et al. (2015) further proposed that educational game designers need to match learner's abilities to game progression in order to support continuous self-directed learning. This can be achieved using algorithmic adaptive learning (Ghosh et al., 2020), which uses an algorithm that changes the mathematical data for each learner. This then presents a unique set of figures each iteration, while maintaining the integrity and content of the learning objectives. As a learner's skills develop, more complex problems are presented with increasing levels of difficulty. Learners are motivated to learn because learning is situated, and occurs through higher order thinking skills of hypothesising, investigating, and reflecting on the simulated world in the GLE (Hamari et al., 2015). Learning objectives (gamified goals) are clearly defined and timely feedback (Boud & Associates, 2010) is available, pushing the boundaries of the learner's knowledge and ability. This equates to Vygotsky's (1978) zone of proximal development (see Section 2.3.4), where learning is scaffolded for continued interest and movement through the threshold. It also reflects the essence of Csikszentmihalyi's (1996) flow theory (see Section 2.3.3).

The more cognitively complex and challenging a learning situation (Biggs & Collis, 1982), the more learners make connections (Biggs, 1997, 2003), become more intrinsically interested (Csikszentmihalyi, 1996), engaged, and perceive value in the curricula (Dewey, 1910). This shift in consciousness through the positivity of success is brought about through a balance in the challenge versus skill dynamic of the flow channel (Csikszentmihalyi, 1996; Redd, 2012). This is the threshold (Meyer & Land, 2006) where the learner begins to feel overwhelmed with the mass of information to surmount, followed by the burgeoning of mastery where transformation occurs, and then the experience of ease and embedding knowledge. Whilst referring to gamers and game play, Csikszentmihalyi's (1996) assertions can also describe engaged learning. From a teaching and learning view of balancing challenge versus skill, education game developers use pedagogical tools to optimise learning. Moseley (2018) describes this design framework as layered learning (see also Raza & Lin, 2019). Learning elements are mapped to game components so experienced players can be challenged, while other players progress and perform the standard skills required to succeed (Moseley, 2018).

While adopting and adapting the attributes of games, GLEs are often enjoyable, but are designed for the primary end purpose of learning. This integration of work and play is flow: "the state of mind characterized by focused concentration and elevated enjoyment during intrinsically interesting activities" (Hamari et al., 2015, p. 171). The use of storytelling to promote flow in learning games, where learners link up a number of different events into a coherent whole, was found by Bopp (2007) to support learning in high school physics students. Learning objectives are achieved through gamified learning activities that are connected by an underpinning story thread (Bopp, 2007) that encompasses curriculum content and affords clear and challenging but achievable learning opportunities, demonstrating constructive alignment (Biggs, 2003; Biggs & Tang, 2011). With the inclusion of a story, the "human essence" of the learner's experience of the teaching is not mediated or lost when translated through the "digital interface" (Warburton et al, 2020). Researchers have consistently found that when students are engaged, they are connected and involved with content, and learning happens (Earl, 2013).

2.4.1.2 Motivation

> Higher motivation, self-efficacy and self-worth
> [ensues] if [students] perceive themselves to be
> competent. (Covington, 2000, p. 181)

In conjunction with engagement, motivation to participate in learning has been widely researched. Researchers have looked to the field of psychology to understand motivation in learning games. While the premise of games is to motivate through fun, creating happiness (and in economic terms, inducing further purchases), the equivalent learning and teaching argument follows that through participating in increasing levels of challenges and concentration, coupled with enjoyment and interest within GLEs, higher intellectual intensity occurs (Ding et al., 2017). The interactive learning environment afforded by GLEs calls on the same psychology used to create motivation in games, to enhance student engagement with the content.

Among the motivational theories with relevance to GLEs are:

- Maslow's (1943) hierarchy of needs, which posits that human behaviour is influenced by motivating factors starting at the most basic physiological needs, and moving through safety, belonging, and self-esteem, to culminate in self-actualisation;

- equity theory from Adams (1963), where individuals seek equity between their inputs to a task or job, balanced by the outputs or the perceived outcomes;

- existence, relatedness, and growth theory from Alderfer (1969), which posits that lower level satisfaction is not a prerequisite for higher level needs, however, this can cause frustration;

- Csikszentmihalyi's (1996) flow theory, where complete absorption and engagement with a physically and/or cognitively stimulating activity leads to feelings of confidence, enjoyment and satisfaction;

- goal setting theory of Locke and Latham (2006), in which they examined goals for effectiveness, mediating effect, relation to self-efficacy, and generality, and the provision of specific feedback to effect increase in performance; and

- Ryan and Deci's (2000) self-determination theory, where intrinsic and extrinsic factors influence motivation.

Common to the majority of these theories is the "recognition of the critical importance of confidence and in particular self-efficacy [which when enhanced can] lead to improved support for student learning and achievement" (Evans et al., 2021, p. 3).

In their self-determination theory motivational framework, Ryan and Deci (2000) distinguished between intrinsic and extrinsic motivation based on the different reasons or goals that give rise to an action. Intrinsic motivation is determined by the human actualisation needs of competence and autonomy. Intrinsic motivation is driven by genuine interest in an activity for its inherent satisfaction (Kheirkhahzadeh et al., 2016). This satisfaction fosters further interest, and leads to better outcomes. The subject is doing something because it is interesting or enjoyable (Schoenau-Fog, 2011). Extrinsic motivation, refers to doing something because it leads to an outcome separate from self (Ryan & Deci, 2000), for example the achievement of grades or attainment of a degree.

In the context of gaming applied to business, Radoff (2011) developed a user motivation model for product design (Figure 4). His parameters of *few* to *many* players correspond to individual and team learning. The *qualitative* and *quantitative* parameters for a business context, retain the meanings in the learning activity, describing the nature of the learning objective desired. An understanding of the four quadrants in his commercial model provides insight into the development of a GLE in order to foster the dimensions which in turn lead to achievement of learning objectives. Team activities provide opportunities and motivation through the need for cooperation and introduction of competition (Christensen et al., 2018; Locke & Latham, 2006). Individual activities create immersion (Csikszentmihalyi, 1996) and achievement states (Ryan & Deci, 2000).

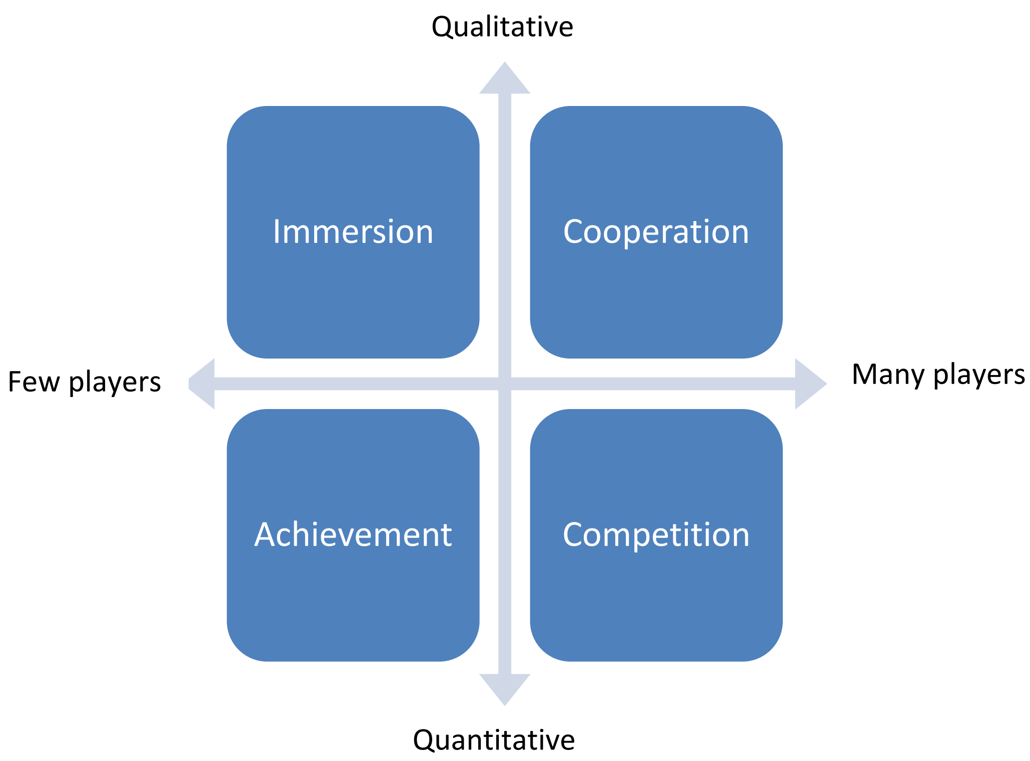


Figure 4 **Evolutionary gameplay motivations (Radoff, 2011)**

To be successful in designing for motivation, GLEs need to include whole of game design, not just game components (Lawley, 2012). Simply applying the game elements of the points, levels, and leaderboards to a learning experience to gamify it, does not guarantee engagement (Laurillard et al., 2013). Learners are discerning consumers and are not likely to be persuaded to engage with a GLE by game components as add-ons and afterthoughts to curriculum design (de Villers, 2010. In a GLE it is the game structure (Fabricatore, 2007), the game content (Hendrikx et al., 2013), and game features (for full discussion see Section 2.3.1) that have the capacity to motivate learners, not just the fact that it is a game. In the same way, GLEs "are not a replacement for thoughtful experience and interactive design; they are an alternate lens for framing that process" (Lawley, 2012, p. 16). The learning experience needs to have some intrinsic value to students to fulfil an expectation of engagement through gamification (Paharia, 2012). It must acceptably answer the learner's question "What's in it for me?" Earlier work on learner behaviour and study processes from Biggs (1987) in his 3Ps model for classroom learning, assists to answer this question in his general model of student learning involving three stages: *presage*, *process*, and *product*. "These factors influence whether a student will take a deep or a surface approach to learning" (Madland, 2014, Chapter 6).

Presage describes the existing conditions that affect the student's approach to learning and their performance. Presage factors include personal (demographics) and situational (institutional) characteristics. Presage shapes the student's process – their motives for undertaking learning and the strategies they adopt (Biggs, 1987) – before the learning activity takes place. This learning process construct "represents the way the student perceives the academic environment" (Biggs, 1987, p. 10) and influences performance and outcomes; that is, the product.

Biggs (1987) further categorised motive and strategy in students' approaches to learning and studying as surface, deep, and achieving, where "students using a 'surface' approach see a task as requiring specific answers to questions, so they rote learn bits and pieces. Students using a 'deep' approach want to understand, so they focus on themes and main ideas" (Biggs, n.d.). Biggs went on to develop the Study Process Questionnaire (SPQ) (1987) "to assess students' approaches to learning, with the addition of an 'achieving' approach, which students use to maximise grades" (Biggs, n.d.). This was later refined to the R-SPQ-2F, in which the SPQ was reduced to the two factors, of deep and surface learning, and with subscales of strategy and motive within each factor (Biggs et al., 2001).

These pre-digital game era findings are equally as applicable in the examination of motivation and strategic approaches of students in GLEs. Students will always learn what they think it is important to learn (Dewey, 1910), and motivation is a multi-dimensional construct (Csikszentmihalyi, 1996). Built in rewarded developmental stages allow learners to reflect on their achievements (Mason et al., 216). This strengthens their sense of competence and self-efficacy and therefore build pathways for future success in academic performance (Beatson et al., 2019; Covington, 2000). By incentivising the collection of achievements through rewards, achievement is the catalyst, but the learning activity is the reward in itself. For example, Lawley (2012) describes achievement to encourage collaboration in an introductory programming class, where every student in the GLE would unlock a reward if 90% of the class passed. Students independently organised study groups and achieved a 91% pass rate.

A GLE can assist leaners to construct a new knowledge base (Schoenau-Fogg, 2011) from an existing presage through a motivating process of actively bridging formal and informal knowledge (Biggs, 1987). However, when game tasks are too difficult motivation and engagement may decline (Schoenau-Fogg, 2011). To maintain confidence, scaffolding that supports learning activities can foster motivation (Chen & Law, 2016). Scaffolding is the process that enables a learner to "solve a problem, carry out a task or achieve a goal which would be beyond his unassisted efforts" (Wood, Bruner, & Ross, 1976, p. 90). "Hard scaffolds are fixed, non-negotiable, and primarily technology-mediated" (Sharma & Hannafin, 2007, p. 30). Hard scaffolds (Chen & Law, 2016) provide fixed information and are often question prompts built into the GLE. They raise awareness of learning objectives to enable connection from the game world to real world, directing conceptual understanding from simplistic reasoning to complex reasoning, and assist in maximising learning and knowledge transfer. "Soft scaffolds are provided by an expert and are customized and negotiable" (Sharma & Hannafin, 2007, p. 30). Soft scaffolds (Chen & Law, 2016) are additional discoveries and timely feedback and supports which guide learner interaction and collaboration (Boud & Associates, 2010). They direct learners to unexplored areas, pose troublesome questions, and encourage multiple perspectives (Thomas & Seely Brown, 2011). "As a motivation tool, technology-enhanced scaffolding can attract and retain attention for a variety of users" (Sharma & Hannafin, 2007, p. 30). Scaffolding is removed once the learner masters the task.

However, even with scaffolding in a GLE, some researchers have reported a negative relationship of higher intrinsic but lower extrinsic motivation for learners in a GLE as compared to those in a traditional learning environment, for example, as Tuzun et al. (2009) found among primary school students studying geography. Also, in Vos et al.'s (2011) elementary school study, the players' motivation to continue play was observed to decline, as the designers' motivation to create more sophisticated games using leading-edge technology increased. These factors serve to strengthen the necessity for GLE integration into the curriculum, not as a discrete learning experience, to achieve motivation for learners (Lawley, 2012).

2.4.2 The result of integrating engagement and motivation

The previous section discussed the two key features that lead to learning and support gamification: engagement and motivation. The following section discusses the types of learning behaviour that result from this integration: *self-directed*, *inductive*, and *adaptive learning*.

2.4.2.1 Self-directed learning

According to Csikszentmihalyi's (1996) flow theory of experience in games (Section 2.3.3), absorption is the sense of immersion a player feels whilst playing, that is their investment in the game. A player's "desire to prolong or continue gameplay is influenced by the affect the game has on the player, stimulating [them] to create new, self-defined intrinsic objectives" (Hooper, 2017). This continuance is reflected in "game-based learning [where] each student [can] have a personalized experience with the same content at his or her own pace" (Kapp, 2016, p. 133).

In his illustratively named chapter: "Choose your level …", Kapp (2016) moves the conversation away from questioning "Are games capable of teaching?", where research has compared game-based learning to traditional learning. Instead, he posits this question as not conclusive, because games are too broad in elements, types, learners, and designers. Kapp (2016) suggested taking a more micro approach with the more appropriate questions: "What features lead to learning and when?"; "What conditions support gamification?"; and "How can they be integrated to ensure learning outcomes are met?" From Kapp's research on existing meta-analyses of literature involving K-12 students, the following guidelines for sound pedagogical integration of GLEs into curriculum are defensible to higher education:

- Embed games into instructional programs: introduce and explain, play, debrief learning and how game events supported learning.
- Align game objectives with learning objectives.
- Include instructional support in the form of learning scaffolds.
- Build in choice and system response for interactivity to engage, as opposed to passive conveyance of content.
- Entertainment influences instructional effectiveness but a learner's engagement with content makes learning more likely to occur.

- Provide unlimited access and encourage extended and repeated game play.

All of these criteria resonate with *gamification as learning* being akin to *assessment as learning* (Earl, 2013; Herrington & Oliver, 2000). Students are encouraged to monitor and reflect on their own learning through activities and assessment items, adjusting to achieve deeper understanding and embed learning. This is supported by continuous real time assessment and feedback (Boud & Associates, 2010) – transparent information for both learners and teachers to facilitate self-paced and self-directed learning (Goffman, 1961; Juul, 2005). "Successful learners are active, goal-oriented, self-regulating, and assume personal responsibility for contributing to their own learning" (Hativa, 2000, p. 52), and a GLE affords capacity for this success within the learning environment. The GLE provides information on student progress by allowing them to review levels or content already completed through replay, thus allowing for new choices, and seeing alternate outcomes (Kapp, 2012). Feedback is instant, acts to instruct and reinforce knowledge, and creates a seamless progression of thought through the content. This demonstration of "progress toward content or skills to be learned is a key element … of the act of moving through content to a clear end point" (Kapp, 2012, p. 140). More than a rubric or an exemplar, this personalised scaffolding of each student's learning within a GLE, fosters self-direction and movement towards achievement of mastery of knowledge and skills (Redding, 2014). Instruction is tailored to needs, preferences, and interests of the student, based on choices and time taken for deliberation and progress. Though not the brief or requirement of a GLE to be entertaining to promote learning, it does depend on "the application of game elements … and thinking to alter [the] content to make it more game-like" (Kapp, 2012, p. 138). The application of a plot-driven narrative, the addition of elements of story, mystery, and characters can alter the student's emotional state and enhance motivation, and thus facilitate learning and performance.

Promoting learning autonomy (Pedder & James, 2012) requires integrating assessment into the GLE by de-emphasising winning in the learning environment, creating team-based games with challenges (learning objectives), for a goal-oriented experience with incremental (formative assessment) features instead of timed or duration bounded activities. Kheirkhahzadeh et al., (2016) acknowledged the challenges that a competitive learning environment posed when they presented their computer science students with a GLE in the form of a contest. While there was evidence of cognitive engagement with 24% of students going on to solve additional challenges, they also found a small proportion of students who simply stopped playing the game once the minimum required points were achieved. Further, they observed lower post-GLE engagement amongst with students who were ranked lower in the contest. This failure to "transition from emotional to cognitive engagement [demonstrates] that motivation for [self-directed learning] is not the same for everyone" (p. 334).

2.4.2.2 Inductive learning

> To state a theorem and then to show examples of it is
> literally to teach backwards. (Stueben, 2003, p. 390)

Teacher centred deductive learning is where the teacher first presents a general concept or rule, explains how it is used, then usually requires students to practice using – not associating then applying – the rule in repeated mechanical problem-solving questions in textbook ends of chapters. The method is widely criticised as a rote learning strategy with emphasis on standardised test preparation, but inadequate focus on meaning (Stueben, 2003). Although it has value in teaching difficult concepts, it concentrates on developing lower order thinking skills of knowledge, comprehension, and perhaps application (Bloom, 1956).

In contrast, inductive learning (Stueben, 2003) is forward focused with emphasis on the development of evidence gathering and critical thinking skills. From his work in the teaching of mathematics, Stueben proposed that students should first be presented with illustrations of how a concept is used, through examples or activities. The teacher then allows the students space and time to formulate the correct conclusion, guiding if necessary toward the general concept or theory. “Learners focus on the structural features of the examples and relate them to the previously received instructional explanations” (Schalk et al., 2020, p. 813). The resultant inductive learning depends on the student’s ability to notice the pattern emerging from the examples presented.

Creativity in play has been well established as a means for providing players with these types of opportunities to explore and learn through doing (Nachmanovitch, 1990; Raphael-Leff, 2009; Shepard, 2012). Equivalent to exploration, the element of discovery enables learners to become aware of what is possible within a GLE, through intrigue, subsequent enquiry, and soft scaffolds, and represents spontaneous creativity across both the cognitive and emotional realms (Dietrich, 2014).

Within the context of the GLE, learners are able to influence and modify their learning pattern. This core principle of emergent gameplay (Juul, 2005; Sweetser & Wyeth, 2005), supports inductive learning. Just as it demonstrates player agency, the degree of control a player has over the game world (King & Kryzywinska, 2006; Tanenbaum & Tanenbaum, 2009), it illustrates *learner agency*, the degree of control a learner has over their own learning experience. In games, players can change game objectives through a manipulation of the rules and mechanics of a videogame to create play that is different from that intended by the developer (Hooper, 2017). While this is not a capacity that is purposely built into a game, it can be additional learning through of discovery and manipulation of the game beyond the ability to change the variables through different choices.

Accepted definitions of a game describe it is an activity governed by rules, where players work towards a stated goal or quantifiable outcome (Crawford, 1982). Likewise, in a GLE, the activity is designed according to the desired learning objectives of the curriculum, to produce quantifiable learning outcomes. Diverging from traditional methods of assessing these learning outcomes, the GLE is capable of producing multiple expressions (Rose &

Meyer, 2002) of the learning objectives, all potentially as valid as each other (Thomas & Seely Brown, 2011). Students pursue solutions to open-ended problems by employing the skills of synthesising, analysing, evaluating multiple modes of information, and critical thinking skills to formulate strategy, problem solve, and propose new avenues of enquiry (Chen & Law, 2016). The learning process and the accumulation of knowledge, is self-regulated and self-managed. The impost is on the teacher to have the means to comparatively assess these various outcomes (Boud &Associates, 2010).

2.4.2.3 Adaptive learning

Web 2.0 (noun)

1. a second generation in the development of the World Wide Web, conceived as a combination of concepts, trends, and technologies that focus on user collaboration, sharing of user-generated content, and social networking. (web 2.0, n.d.)

Adaptive learning as a pedagogy uses computers as interactive teaching devices (Arapi et al., 2007), to determine the allocation of human and mediated resources in the form of learning scaffolds (Chen & Law, 2016; Sharma & Hannafin, 2007) pursuant to the particular needs of each learner. The presentation of educational material is adapted according to students' learning needs, as indicated by their responses to questions, tasks, and experiences within a gamified learning environment. This learner agency gives the learner the power to act and involves activity and initiative over and above the mere transmission of inputs from teacher to learner (Core Education, 2014; Hall, 2008). Student choice in path and pace through the learning material managed by the GLE supports connectivism that “inspires [them] to make changes in their practice” (Bell, 2020, p 112). Recognising that traditional, non-adaptive pedagogies are incapable of delivering this type of tailored learning, adaptive learning endeavours to transform the learner from passive receptor of information to collaborator in the educational process, akin to the interactivity experienced with Web 2.0 (Arapi et al., 2007; Brusilovsky & Peylo, 2003; Hall, 2008).

In comparing an online game-based simulation for stock trading with traditional pedagogy, Ding et al., (2017) found that adaptive learning improved learning by dividing the content and activities into small chunks. This is resonant with Mostyn's (2012) application of cognitive load theory and procedural efficiency to provide instant positive reinforcement, and scaffolded learning. Ding et al. (2017) upheld the potential of games in tertiary learning, when students were active participants in the learning process, the content and the process was intrinsically interesting, clear goals were stated, and timely feedback was available. Ding et al. (2017) provide a summary of gamification learning theory (Table 1) matching the components of learning to the behaviour observed in a GLE.

Table 1 **Summary of Gamification Learning Theory (Ding et al., 2007, p. 149)**

Components of Learning	Gamification
The learner	Conscious individual
Motivation	Inrinsic[/extrinsic]
Knowledge	Internal/external
The learning process	Systematic personal processing
The teaching focuses on	The environment and the cognitive process of learners
Engagement	Group-based
The learning path is guided by	The teacher (establishes different paths) and the learner (chooses one path)
The attitude of the teacher	Proactive
The attitude of the student	Proactive
Feedback	Group-based

The research of Ding et al. (2017) looked at teams in a GLE and therefore identified the components of group-based engagement and feedback, however, these apply as equally if it is an individual learner progressing through a GLE. The learner may be working alone, but the feedback scaffolding afforded can be programmed to appear whenever any learner attains (or fails to attain) a certain place in the GLE. In the case of geographically diverse learners, the physical perception of the engagement of the GLE can be individual but the arena for learning may involve many participants, both non-player characters and other learners, working together and separately.

Individual and collaborative GLEs require learners to develop social communication skills in order to convey and combine their individual learning for the success of the team. In GLE, a constructivist teacher creates the context for learning that engages learners in interesting activities that encourage and facilitate learning (Laurillard et al., 2013). Providing assistance in the learners' learning process, in the form of hard and soft scaffolding, increases understanding (Chen & Law, 2016). Although the literature on the impact of educational games on motivation and learning performance is still unclear, the additional scaffolding available in the computer supported environment of a GLE, in the role of a continually available *teacher*, may improve learning. GLE participants are motivated to learn because they are engaged in virtual worlds where, via the design of scaffolds (Chen & Law. 2016) providing timely feedback on progress (Boud & Associates, 2010), they see and understand immediate connections between the learning experience and real world of work (Herrington et al., 2003; Kaider et al., 2017; Oliver, 2015; Prensky, 2001, 2005), thereby leading to increased levels of learning.

As defined in Section 2.4.1.2, hard scaffolds are fixed information and question prompts. In a GLE these hard scaffolds (Chen & Law, 2016) allow the learning designer to introduce cognitively more complex tasks in the learning process. Learners then proactively seek out needed information, viewing the acquisition of knowledge as a systematic and controllable process and taking responsibility for their own achievements. They self-regulate using a "self-oriented feedback loop" (Zimmerman, 1990, p. 5) where they monitor the effectiveness of their own learning processes, methods, and strategies and react by adapting and changing behaviour.

Soft scaffolds are spontaneous and timely feedback mechanisms (Chen & Law, 2016) and supports which guide interaction and collaboration with the GLE. These are usually in the form of question prompts from the teacher. They can be used to focus learners' thinking on effective and correct ways to problem solve a particular task. Soft scaffolds allow the teacher to manage timing, guide the structure of the learning, and promote flow, while at the same time affecting learning attitudes, level of interest, and technology acceptance. Soft scaffolds interjected into the GLE encourage the learners to discuss, reflect, and integrate content knowledge. Soft scaffolds support reflection, and learner to learner interaction and collaboration which mitigates the short comings of hard scaffolds (Chen & Law, 2016).

Using hard and soft scaffolds (Biggs, 1987; Kapp & Driscoll, 2009), the teacher assists learners as they approach problems, interjects with troublesome concepts to disrupt existing beliefs and advance critical thinking, and provides formative feedback. The use of hypothetical scenarios grounded in real world situations are interesting, relatable, and produce satisfying learning outcomes. Learners make sense from hard scaffolds and elicit connections between the GLE scenario and real world situations, when concepts and question prompts (soft scaffolds) are well structured (Chen & Law, 2016). Used together, hard and soft scaffolds create "collaborative opportunities to provide and receive feedback, co-construct ideas, resolves dilemmas, negotiate meaning and make team decisions" (Chen & Law, 2016, p. 1203). Using a mix of hard and soft scaffolds as teacher designed communication tools (Löhner et al., 2005), affords learners the reflection and discussion points for the collaborative learning activities.

Having looked at self-directed, inductive, and adaptive learning behaviours that result from integrating engagement and motivation into learning design, the next sections examine *learning styles* and the active strategies learners employ, which also inform the learning design of GLEs.

2.4.3 Learning styles

Learning styles are collectively a group of contested theories describing differences in individuals' learning. While labelling and grouping learners into categories raises administration and ethical issues, individuals differ in what mode of instruction is most effective for them (Pashler et al., 2008). Soflano et al. (2015) analysed the *learning preferences* of a group of database programming students, using an adaptive game-based learning application, to examine if their learning preferences fluctuated during the learning process. They found that the results from participants' learning style questionnaires were not always consistent with the learning style they used to engage with the game. It was, however, most often the style they used for their first activity, the style varying thereafter depending on the number of mistakes made. The alternate learning preferences adopted subsequent to the first activity were perceived to interact and respond more congruently with the learning environment (Keefe, 1982).

Although the measurement and consistent classification of learning styles has its detractors, this does not diminish their value as a reference point (Felder, 2010). Subsequent to Kolb's (1981) learning style inventory of accommodator, converger, diverger, assimilator, the classification of students in different disciplines, to best match teaching approaches has been supported (e.g., Felder, 2010; Wilson & Hill, 1994). Accounting and finance students tend to be convergent learners who conceptualise and experiment, employing linear, operational, and surface thinking patterns. However, restricting teaching methods to accommodate these learners likely limits the students' opportunities to develop competence in other learning styles. A range of teaching approaches and resources is essential (Gordon et al., 2011).

In an examination of the characteristics of students who enrol in accounting and finance disciplines, Scott et al. (1998), analysed the early development of professional accounting capabilities in a sample of undergraduate potential accounting majors. They found that students indicating a preference for accounting cited more previously completed courses or experience in written and oral communication skills, data processing, computer programming, and math skills, and fewer in humanities and arts. Scott et al.'s (1998) composite profile of the capabilities needed by accounting graduates extended the technical skills that draw students to accounting, to include the ability to apply accounting knowledge to solve real world problems.

2.4.3.1 Universal design for learning

Complementing research on learning styles, universal design for learning, a pedagogy proposed by Rose and Meyer (2002), outlined the creation of curriculum to include a broad selection of teaching and learning resources, available simultaneously, to appeal to all learner preferences and needs (Gordon et al., 2011). Universal design for learning "guides the design of instructional goals, assessments, methods, and materials that can be customized and adjusted to meet individual needs" (http://www.cast.org/our-work/about-udl.html#.XZ1ppS1L1QI). The principals of universal design are:

1. Multiple means of representing content and information to learners in various ways,
2. Multiple means of engagement to stimulate interest, challenge, and motivate students to learn, and
3. Multiple means of expression to provide learners alternatives for demonstrating what they know. (Gordon et al., 2011, Rose & Meyer, 2002)

Together these principles are applicable in higher education to produce fully accessible programs for all learner preferences (Burgstahler & Cory, 2010).

2.4.3.2 Learner preferences in digital pedagogy

> Learning style refers to an individual's preferences and strategy in learning to effectively and efficiently achieve the learning objectives. (Soflano et al., 2015, p. 106)

Educationalists acknowledge different student preferences in ways of learning and processing information (Kolb, 1981), study processes for learning (Biggs, 1987), the benefits for delivering learning to match student preferences (Smith & Renzulli, 1984), and the place for computer-assisted learning for student learning preferences (Miller, 2005). In distilling an operational definition of learning style in computer supported learning, research traces a trajectory through Kolb's (1981) learning styles (combining elements of concrete experience, reflective observation, abstract conceptualisation, and active experimentation), Dunn's (2003) visual, auditory, kinaesthetic model, Honey and Mumford's (1989) personality traits Big-5 Model, to the Felder-Silverman model (1988) (Table 2). This model "has been widely used in technology enhanced systems, … its reliability and validity have been tested, [and it] represents elements of most models which indicates the generalisability of the model" (Soflano et al., 2015, p. 107). Additional to its antecedent models, reflection is included in the elements of the final Felder-Silverman model. This deductive practice is the pivotal point where adaptive learning can take place.

Table 2 **Elements of Felder-Silverman's learning style model**

Main elements	Sub-elements A	Sub-elements B
Perception	Sensing: prefer to use existing ways than exploring new ways, prefer to learn concrete materials, careful with details	Intuitive: prefer to try new ways, prefer to learn abstract material, not careful with details
Input	Visual: prefer to learn materials presented in pictures, charts, or diagrams	Verbal: prefer to learn materials by text or audio, having difficulty with visual style
Processing	Active: learning by doing, socially oriented	Reflective: learning by thinking it through, solitary orientation
Organisation	Sequential: building up from specific knowledge until a more general knowledge is attained	Global: learning from a general knowledge into a more specific knowledge

Note. Adapted from Felder and Silverman (1988).

Some research has sought to make connections between learning styles and technology enhanced learning. Karimi (2016) explored mobile-learning (m-learning) adoption in self-directed learning in undergraduate business and marketing programs and found results suggesting individuals' learning style and perceived playfulness influence m-learning in both formal and informal contexts. Self-directed learning in m-learning embraces learning that occurs outside the classroom, is structured by the learner, and is influenced by their position in the technology acceptance model (Venkatesh & Davis, 2000): where technology acceptance is a function of the user's perceived usefulness of the technology, the perceived ease of use of the technology, their intention to use the technology, and their usage behaviour. The formal learning context is within the constraints of the designed curriculum with teacher supplied resources. The ubiquitous nature of publicly available information, resources, and mobile devices, opens the informal learning context to be anything else. Together, these contexts are informed by Venkatesh et al.'s (2003) unified theory of acceptance and use of technology model, which "posits three direct determinants of intention to use (performance expectancy, effort expectancy, and social influence) and two direct determinants of usage behavior (intention and facilitating conditions)" (p. 467).

Using a survey instrument that included questions from Kolb's Learning Style Inventory and Venkatesh et al.'s (2003) unified theory of acceptance and use of technology model, Karimi (2016) collected data on the learners' innovativeness (creativity), playfulness, performance, and effort expectancy, using one model with, and one without, learner styles. For the dimensions of performance expectancy and effort expectancy, Karimi (2016) found learning interfaces – the methods used for learners to interact with the content and help them navigate through a course – can act as barriers and therefore affect adoption. With regard to perceived playfulness, or in the GLE the process of performing the activity, Karimi (2016) found this to be related to intrinsic motivation (Ryan & Deci, 2000) and flow theory (Csikszentmihalyi, 2008), and could be matched to learner characteristics. Specifically, Karimi found the self-directed learner was actively engaged in the learning process, exhibited an accommodating learning style, and relied on fellow learners to help them solve a problem, often in an informal context. Learners who relied on logical analysis and reflection displayed an assimilating learning style, preferring, and performing better in, formal contexts (Karimi, 2016). Although not the sole determinant, there is scope for the utilisation of learning style as an entry point for GLE designers to centre the attention and arouse the sensory and cognitive curiosity of the learner (Karimi, 2016) for focused attention, that is absorption in activity.

2.4.4 Active learning strategies

Active learning strategies where learners engage in activities such as reading, exercises, team work, decision making, and problem solving, foster the higher order thinking skills of analysis, synthesis, and evaluation. *Experiential learning*, *cooperative learning*, and *authentic learning* are three examples of active learning that translate into the design of the GLE.

2.4.4.1 Experiential learning

> This perspective on learning is called "experiential" for two reasons. The first is to tie it clearly to its intellectual origins in the work of Dewey, Lewin, and Piaget. The second reason is to emphasize the central role that experience plays in the learning process: [To] suggest through experiential learning theory, a holistic integrative perspective on learning that combines experience, perception, cognition, and behavior. (Kolb, 1981, pp. 20-21)

Communication and team work skills – the emotional intelligence to "organize, recognize, use, and manage emotions and people" (Daff et a., 2012, p. 627) – are necessary attributes for accounting students to enable them to be strategic thinkers and decision makers, team members, client communicators, and leaders. Being able to work with the emotions of others has the potential to create graduates who are more than data processors, and at the same time attract students to the professions in accounting and finance (Daff et al., 2012). Students report increased skill development in listening and negotiating after well-structured cooperative (team based) learning activities (Christensen et al., 2018). Communication skills positively impact the effective and efficient achievement of common tasks (Christensen et al., 2018; Cragan et al., 2009). This act of experiential learning, that is, taking the students through experiencing, reflecting, thinking, and acting (Kolb & Kolb, 2005), holistically combines technical or generic skills with emotional intelligence (or *soft skills*), using a range of delivery and engagement methods: simulations, role-plays, case studies, videos (Daff et al., 2012).

In the field of business analytics, Grund and Meier (2016, p. 155) asked the question "Can we become better decision makers by playing video games?" Their research looked at the vicissitudes of serious games and dedicated business information software, and how these game-based pedagogies could support and foster decision making. They found that, while the decision-making process could be supported by GLEs, most of the platforms being used were inserted into the curriculum for reporting and analytic purposes only, not designed and developed as a cohesive unit to also include information gathering and evaluation phases. The case for *adaptive* GLEs in business education was also strengthened on three other fronts: (1) the execution of decisions may be problematic, lacking information or resources; (2) the difficulty of designing for multiple steps and outcomes; and (3) learners do not formulate decisions in isolation (Grund & Meier, 2016).

2.4.4.2 Cooperative learning

To borrow from the psychology of play (Parten, 1933), associative play or cooperative learning occurs when the learner begins to engage with other learners. The learning may still remain a solitary learning endeavour, but can be influenced by the activities and presence of other learners. This type of learning occurs when a learner becomes immersed in the activities of other learners, sharing resources and information. The learning is not in isolation.

On serious games, Egenfeldt-Nielson et al. (2008) held that players could engage in play for more serious purposes; that is, learners could focus on the learning outcome or product, not the just the fun or emotion of play. According to Piaget (1952), incentives are the starting point of play, with motivating factors extrinsic to the current activity (serious or non-serious) included in addition to intrinsic elements of the activity. Vygotsky (1978) added that imaginary situations and rules contribute to cognitive and social development in children.

2.4.4.3 Authentic learning

When students suspend disbelief, they willingly suspend their critical faculties and sacrifice the realism and logic of the real world for the sake of enjoyment in the game world (Csikszentmihalyi, 1990), and see the complexity and real world meaning of the game activity (Kaider et al., 2017). It is then that engagement with the content and subsequent learning (Shulman, 2002) can occur. Thus, authentic curriculum and learning must be contextually matched, mapped, and integrated with real world and work content, for students to be persuaded to participate. Further Barab et al., (2000) argue that authenticity is the flow of interactions among all the elements of learning technology tools: learner, activity, and environment.

All three of these elements are contained in the operational definition of authenticity in learning of Herrington et al. (2003); employing real-life problems, with real-world relevance, using learning activities that are generative – moving from simple to complex – and requiring students to investigate, define, and conceive of other questions to be answered. Among the characteristics of authentic activities identified by Herrington and Oliver (2000) in the development of their instructional design framework for authentic learning environments, those that most resonate with, and are demonstrated in, GLEs are:

- *Real-world relevant activities matched to tasks or scenarios encountered by professionals in the discipline*.

For example, Gazillionaire (http://www.gazillionaire.com/index.php) where the goal is to build from a small enterprise to a global corporation.

- *Loosely defined activities open to multiple interpretations, competing solutions, and diverse outcomes.*

  Informatist (http://www.informatist.net/Login.aspx) a free online business simulation game, with players of various levels and experience, world-wide.

- *Activities that span whole of unit or course, with formative development tasks which build to a final solution as an assessment item.*

  Voki for Education is an example of a digital platform which allows learners to create and build their own "customizable speaking avatars … that enhance classroom instruction, class engagement, and lesson comprehension [and can be used] for assignment submissions and ePortolio assembly. (https://itunes.apple.com/au/app/voki-for-education/id1106010700?mt=8)

- *Activities where students take on different roles and perspectives, challenging held perceptions and beliefs.*

  For example, Democracy 2, where the first-person player takes the role of Prime Minister or President of a democratic government, creating policy and dealing with stakeholders. (https://store.steampowered.com/app/218040/Democracy_2/)

- *Team based learning requiring collaboration.*

  EVE Online (https://store.steampowered.com/app/8500/EVE_Online/) provides a massive multiplayer online role playing game (MMORPG) opportunity, where players share a virtual game world and engage in unscripted adventure and competition with other players.

- *Opportunities to reflect on choices and consequences, and consider implications of alternate actions.*

For example Uplink (https://store.steampowered.com/app/1510/Uplink/) where the first person player is an agent whose “tasks involve hacking into rival computer systems, stealing research data, sabotaging other companies, laundering money, erasing evidence, or framing innocent people.”

- *Activities that are assessment as learning, both ongoing self-assessment by the student, adjusting activities, and the monitoring by the teacher, providing feedback, to facilitate learning and achieve learning objectives*.

  To some extent this is demonstrated in the online plagiarism game “Goblin Threat” (Kier, 2019) where students “find and click on ‘goblins’ who ask various questions about plagiarism” (e1). They have to “receive a ‘pass’ [from] playing the plagiarism prevention game in order to unlock the quizzes” (e5) which is an assessment items for the psychology course they are undertaking.

2.4.5 Learning design of gamified learning experiences

Hooper (2017, p. 25), on his research about extended game play, observed that “games generally include some form of reward system, which is used to create a positive association of success, and inform the player of negative or unwanted behaviours. Videogames are a significantly different medium, and are far more complex. Videogames utilise computational processing to receive input from one or more players, manage rules and game objects and objectives”. To examine learning design of gamified learning experiences, this can be reframed in pedagogical language by substituting the *game* words for *learning* words: *Programmes of learning* generally include some form of *assessment* system: summative, which is the positive measure of success; and formative, monitoring learner progress, informing via feedback, and modifying teaching and learning activities to improve learning. *GLEs* are a significantly different medium, and have the scope to be far more complex. *GLEs* utilise game mechanics and structure to receive input from one or more *learners*, and allow *teachers* to manage *learning objectives*, *activities*, and *assessment tasks*.

Fundamentally, learning activities drive student learning towards reaching the stipulated learning outcomes. In GLEs the learning activity is a generative game-based activity, or situated action, still influenced by the beliefs and values of the teacher and learning designer (Lameras et al., 2015).

By introducing learning design as a fundamental element of GLE design Lameras et al. (2015) described how learning design features and game properties can be planned, designed, and implemented. He proposed this through a process of reverse engineering learning activities, outcomes, feedback, and teaching techniques together, and matching these to the game attributes of rules, goals, choices, challenges, collaboration, and competition. The distillation of learning occurrences experienced through these attributes, observed by the learner's game pathway and time spent and measured by their accumulation of experience points and progress through levels, in combination with the representation of content for enhancing learning experiences, is a *gamified curriculum* (Deterding et al., 2011).

Design for learning places the student at the centre of learning where the student learns what they consider important (Dewey, 1910), and what the student does is most important (Biggs & Moore, 1993). Learning tools and resources are included to achieve specific learning outcomes (Beetham, 2008). In design for learning in the context of a gamified curriculum, the tools and resources of game like design (Bell, 2016) are game mechanics and dynamics (see Section 2.3.1).

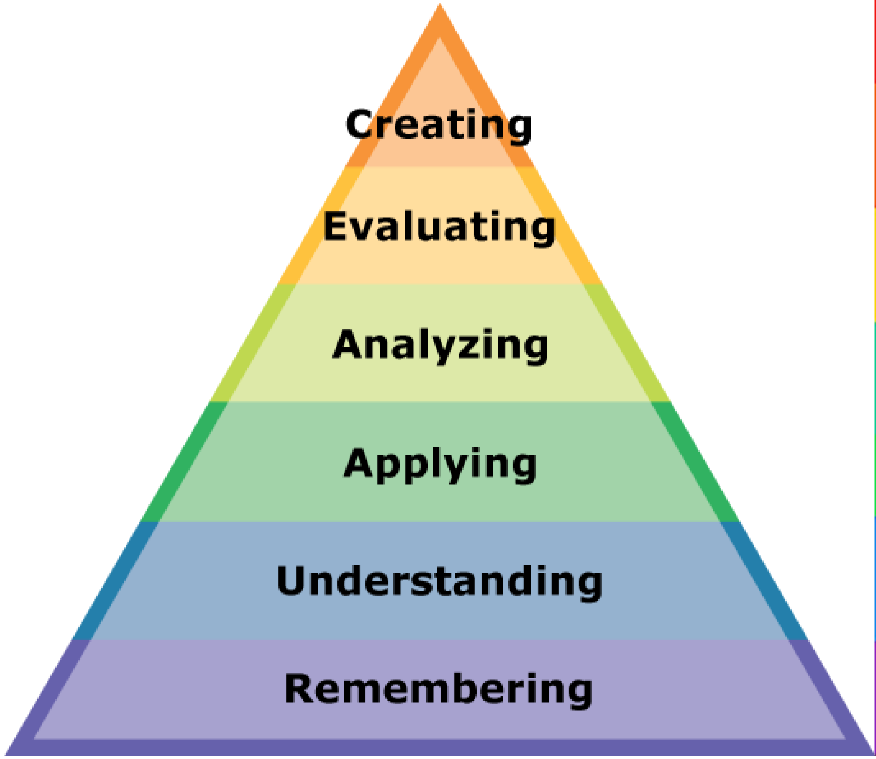
Current literature looks at the broad themes of research into gamification in higher education in isolation: learning design (Beetham, 2008), game mechanics (Juul, 2005; Lameras, 2015), linking learning with game attributes (Damsa, 2016; de Byl & Brand, 2014; Kapp, 2012), education design for games (Millwood, 2014), and engagement and motivation (Hamari et al., 2015, Radoff, 2011), but they have not been looked at as a cohesive group. This research draws these themes together to formulate a framework for the learning design and evaluation of the GLE (see Section 3.3.7, Generalised theoretical framework).

In the following section the current models for learning outcomes, the existing *taxonomy*, *digital taxonomy*, and the *flipped learning model*, are discussed as elements for developing a GLE framework.

2.4.6 Taxonomy of learning outcomes

Mapping Bloom's expanded taxonomy of learning outcomes (Figure 5) (Anderson et al., 2001; Bloom, 1956) of the cognitive domain (i.e., the intellectual ability to know and organise ideas, using active learning levels) and Bloom's digital taxonomy (Churches, 2009) (which added digital verbs to describe technology processes) to game attributes, provides a broad framework of what learning activities and therefore outcomes are possible. In Figure 5 the functional levels of the learning outcomes are populated with descriptive learning verbs and are shown in parallel with integrated gamified activities that advance learning and knowledge.

2.4.7 Existing taxonomy and digital taxonomy



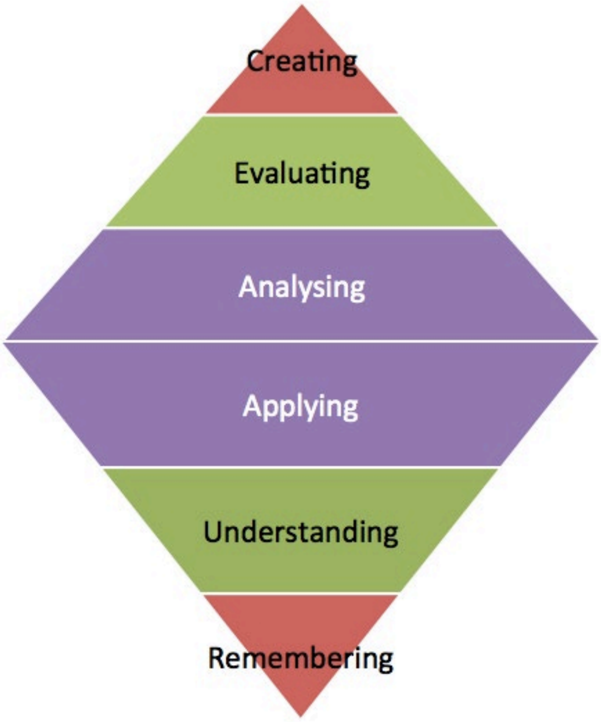
Functional Levels	Activities with digital tools	
Publicly sharing, publishing, broadcasting	Contributing to open social networks, publishing, broadcasting, networking	Higher Order Thinking Skills
Designing, constructing, planning, producing, inventing, devising, making	Programming, filming, animating, blogging, video blogging, mixing, re-mixing, wiki-ing, videocasting, podcasting, directing	
Checking, hypothesising, critiquing, experimenting, judging, testing, detecting, monitoring	Blog commenting, reviewing, posting, moderating, collaborating, refactoring, testing	
Comparing, organising, deconstructing, attributing, outlining, finding, structuring, integrating	Hacking, mashing, linking, validating, reverse engineering, cracking	
Implementing, carrying out, using, executing	Running, loading, playing, operating, uploading, sharing with group, editing	
Interpreting, summarizing, inferring, paraphrasing, classifying, comparing, explaining, exemplifying	Boolean searches, advanced searches, blog journaling, tweeting, categorizing, tagging, commenting, annotating, subscribing	
Recognizing, listing, describing, identifying, retrieving, naming, locating, finding	Bullet pointing, highlighting, bookmarking, group networking, shared bookmarking, searching	Lower Order Thinking Skills

Figure 5 Bloom's revised taxonomy of learning outcomes

Note. Revised taxonomy triangle (Anderson et al., 2001; Bloom, 1956). Functional levels (Anderson et al., 2001). Activities with digital tools (Churches, 2009).

2.4.8 Flipped learning model

Diverging from Bloom, where the model suggests most learning time and effort is spent in the lower order thinking skills demonstrating learning outcomes of remembering and understanding, the flipped learning model of Bergmann (2016) (Figure 6) for application in undergraduate learning, suggests the pyramid shape of Bloom's taxonomy should be more like a diamond. Flipped learning is a pedagogical approach where direct instruction is moved from the group learning space to the individual learning space (Bergmann, 2016). This transforms the group space into a dynamic learning environment. In Bergmann's model most of what goes on in the active or gamified learning classroom, is in the middle levels of Bloom's taxonomy of learning outcomes: the applying and analysing bands. This aligns with AQF level 7 criteria (https://www.aqf.edu.au/aqf-levels): Bachelor Degree descriptors, where courses are designed to ensure learning to these levels. He therefore shows these middle bands as larger areas to indicate more learning time and effort spent in these learning activities, with lower order skills of understanding and remembering, and higher order skills of evaluating and creating, indicated with smaller areas above and below where the majority of time and effort is expended.



2.4.9 A new culture of learning

Some research has examined the way a gamified learning curriculum is represented. Within the applying and analysing bands of functional levels and activities with digital tools (Figure 5) are finding, comparing, integrating, playing, sharing, and editing. Connolly et al., (2009) asserted that these activities within GLEs can have variable expressions of the same learning outcomes. These expressions impact on the learner, and others in the learner's group or game world, as described in Thomas and Seely Brown's (2011) *new culture of learning*. Thomas and Seely Brown (2011) recognised that games have uncertainty built into them via the choices and decisions available, and that there is not always one correct answer. Instead, the curriculum or learning game world is an arena where the content is bounded and a synergy of learning takes place as *collective indwelling* in a fluid way defined as "the feeling and belief that group members share a tacit understanding of one another, their environment, and the practices necessary to complete their task" (Thomas & Seely Brown, 2011, Loc 1621 of 2399). The teacher or learning designer sets the boundaries or parameters, and exit points from the learning activity are multiple expressions of learning (Gordon et al, 2011) in the form of assessments. In fact, there may be no finite destination answer, just a progression of increasingly complicated questions or tasks. This structure is likened to the rubric of assessment grading (Brookhart, 2013) where levels of achievement or performance are situated on a matrix. The output of one learning game play activity, becomes input for the next higher level, as the learner reflects, self-assesses, and receives peer assessment. All these formative assessment (see Section 2.5.3) instances combine for a total *assessment as learning* (Earl, 2013; Herrington & Oliver, 2000) experience evaluated by the teacher. The formative assessment opportunity is also the challenge of assisting learners to identify learning problems and misconceptions, and then to provide in-game feedback (Lameras et al., 2015). Authentic assessment, where learners use and apply knowledge and skills in real world contexts, requires naturalistic ways of scaffolding feedback within the game (Vos et al., 2011). It is dependent on knowledge already gained and predicative on the direction the knowledge should lead the student, that is, from one game level to the next. Meaningful feedback provokes reflection (Swanson et al, 2011). It is instrumental to knowledge construction and unlocks further development. The feedback progress indicators in the serious games SCAMP (social, cognitive, affect, motivational, progress) model, gaming examples, and mechanics are shown in Table 3 (Jones et al., 2014). These can be as simple and ubiquitous as the social indicator of *liking* via a “thumbs up” button, or more the complex and contemporaneous example of the *progress* indicator via a visible cache of achievements or progress bar.

Table 3 **Feedback performance indicators in serious games**

Feedback Performance Indicator	Gaming example	Game mechanics
Social	*Liking* game progress through a discussion thread.	Feedback buttons and suggestions, and emoticons.
Cognitive	Selection of correct choice from in-game dialogue script.	Prompts, in-game hints, game levels.
Affect	Visual emotion cues and indicators for correct and incorrect actions.	Scoring and achievements.
Motivational	Winning currency or points from completion of game or levels.	Experience points, game levels, lives and virtual currencies to buy game items from online inventory.
Progress	Visual progress of game cache of badges and attributes to highlight learning mastery.	Progress bar, achievements, dashboards.

Note. Adapted from Jones et al., 2014

Feedback scaffolds learning activities for constructivist learners (Biggs, 1987) to build on their existing schema. Built-in supports are expressed in terms of progress bars and dashboards (Jones et al., 2014). As learners reach certain numbers of points, embedded hints support their advancement, allowing for more movement within the GLE and the ability to achieve more complex levels of mastery (Lameras et al., 2015; Vos et al., 2011). The language of gaming already mirrors that of cognitive learning as in Vygotsky's zone of proximal development (for full discussion see Section 2.3.4), with support mechanisms less frequent as more experience and higher levels of achievement are attained. However, to scaffold learning, multiple means of representation of information

(Rose & Meyer, 2002) and feedback in the form of navigational tools (Jones et al., 2014) are utilised by the content expert working with the learning designer.

The relationships of the stakeholders to the learning design of the GLE are illustrated in Figure 7. To inculcate a state of *flow* (Csikszentmihalyi, 1990) (see also Section 2.3.3), the instructional designer and the content expert balance learning with fun. This is the compelling aspect of enjoyment of the tasks and challenges: the "state of deep concentration in which thoughts, intentions, and feelings are focused on the same goal" (Csikszentmihalyi, 1990, p. 41). At the intersection between digital learner and instructional designer, game mechanics and attributes allow access and engagement with the learning platform. In the relationship between the content expert and digital learner, scaffolds facilitate learning. The centre of the diagram, where the GLE is situated, is achieved with the provision of a conceptual framework, shaped through consultation with the digital learner. The framework then guides and assists the content expert and the instructional designer to work together to design, develop, and evaluate GLEs. In this *learning by design* approach championed by Koehler and Mishra (2005), "every act of design is always a process of weaving together components of technology, content, and pedagogy" (p. 135). Just as "understanding and negotiating the relationships between these three components of knowledge" facilitates "true technology integration" (Koehler & Mishra, 2005, p. 134), so does an understanding and negotiation of the relationships between the stakeholders and what they can contribute in a group design situation. It is also here where "cognitive load theory uses a combination of information and cognitive structures to guide instructional design" (Sweller, 2002, p. 1501).

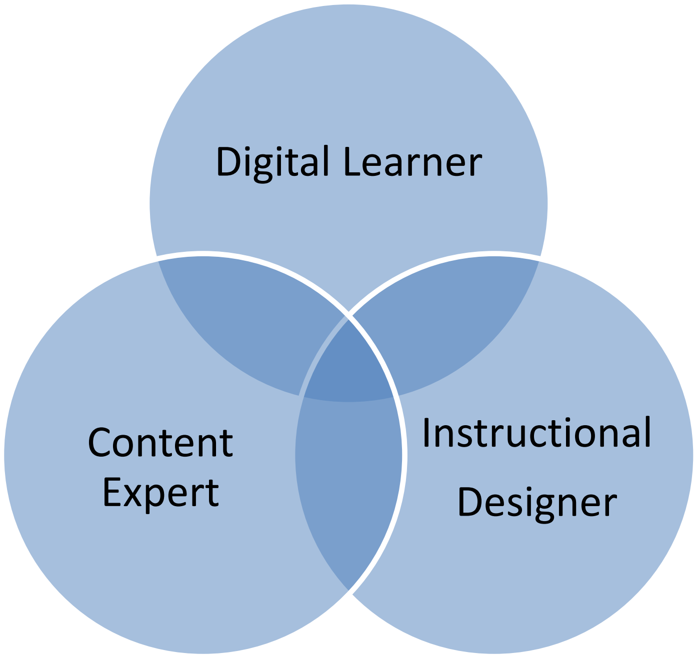


Figure 7 **Interrelation of stakeholders to the GLE design**

2.4.10 Integration of theory and elements

Some research has investigated the challenges of integrating the theory and elements of gamified learning into curriculum. Incorporating games into a harmonious part of a bigger ecosystem of learning – coupling game designs, learning principles, student engagement, and learning outcomes – can be to the detriment of how the game itself functions in an educational context and the impact on teachers' time and resources (Marklund & Taylor, 2016). This is gaming into curriculum, not gaming as curriculum, and misses out on the learning opportunities of a synerginistic game-based curriculum (Marklund & Taylor, 2016). Research to date obfuscates the problematic implementation of GLE. This can only be overcome by understanding the constraints of teachers (time, money, and technology competency) and technology capacity, for a viable gamified curriculum (Laurillard et al., 2013). This thinking complements one of the tenets of assessment (Boud & Associates, 2010), where assessment must be doable for the teacher in terms of technological, pedagogical, and content knowledge expertise (TPCK) (Koehler & Mishra, 2005), and time.

2.4.11 Consideration of the pedagogical framework

This section now considers the learning theories that provide the pedagogical framework for higher education and particularly online delivery. The online delivery mode of higher education instruction constantly reshapes how, what, and when learners learn (Allain 2020; Walsh et al., 2020). Understanding the impact online delivery has on teaching practices and learner engagement in learning in the disciplines of accounting and finance is critical (Hancock et al., 2016).

There are many psychological and learning theories that can provide a framework for this research. The most dominant one associated with educational technology and technical concepts is constructivism (Jonassen et al., 1995; Jonassen et al., 2002). The constructivist approach emphasises construction of knowledge from experience and lends itself to student-centred action learning environments.

This review now investigates *constructivism*, for the development of a theoretical framework for the project. Aligning game genre and mechanics with learning theories for student engagement and enhancing performance, the research also demonstrates a gamified curriculum model where:

> Learning should be viewed in terms of an environment – combined with the rich resources provided by the digital information network – where the context in which the learning happens, the boundaries that define it, and the students, teachers, and information within it all coexist and shape each other in a mutually reinforcing way. (Thomas & Seeley Brown, 2011; Location 340)

2.4.12 Constructive learning

There are two philosophies of learning related to constructive learning: constructionism (social construction of knowledge) and constructivism (individual construction of knowledge). While they share elements, they are different. Rob and Rob (2018) in their efforts to clarify the confusion between the two philosophies, stated:

> A constructivist teacher sets up the learning environment for students that fosters individual learning and presents a problem to be solved, while the students go on their own way to produce a personally meaningful artifact without any further teacher's intervention. [On the other hand], the constructionist teacher sets up the environment for collaborative learning for students, then he or she defines the problem to be solved and the meaningful end product to be developed, and then guides them to reach towards the goal. Student assessment supports this difference. (p. 278)

In their investigation of the dilemma between constructionism and constructivism, Rob and Rob (2018) went on to conclude that "while the constructionist approach can be applicable across a curriculum and in any level of education, the constructivist approach might be appropriate for early or childhood education" (p. 287). While referring to school age early education, the application of constructivism to threshold concepts, as core concepts of learning (Meyer & Land, 2006) is therefore pertinent. Higher education research and practice is crowded with references to *constructionism*, and as such is worthy of and requires investigation into its derivation. Crotty (1998) regarded:

> [A]ll knowledge, and therefore all meaningful reality [as] contingent upon human practices being constructed in and out of interactions between human being and their world, and developed and transmitted within an essentially social context. (p. 42)

However, meaning is not just happened upon and discovered but constructed, that is it is not resident in an object but rather only emerges when consciousness engages with it. From an education design perspective, Millwood (2014) finds meaning in an *expressive* constructionist stance to:

> [S]upport creative decision making in the design of learner-centred, technology-enhanced education, as a design practitioner in technology-enhanced learning ... [seeking] analytical and descriptive means to improve designs through effective design and development processes. (p. 3)

Individual meanings are then constructed by learners as they engage with the content they are interpreting. Meaning only emerge once the learners have content to work with and constructionism brings together their experienced reality to build new knowledge and ways of understanding.

> The central claim of constructionism is that if the learning is situated in a meaningful context with a meaningful goal in view, the learner can use just the direct feedback from the environment to improve their actions, without needing further external advice or guidance. (Laurillard, 2016, p. 36)

Constructivism as a learning theory holds that learners construct their understanding and knowledge, through experience and reflection. Applied to pedagogy, constructivism draws on the cognitive psychology theory of Piaget (1952) emphasising personal construction by individual learners, and shifts towards a Vygotskian (1978) learning perspective of social construction within a community of learners and to a view of learning as a process of enculturation.

> Constructivists emphasise the instrumental and practical function of the theory [of] constructionism and knowing. This constructivism is primarily an individualistic understanding of the constructionist

> position. Social constructivism [as a subgroup emphasises] not focusing on the individual mind but outward to the social constructions of meaning and knowledge, as a more adequate description of knowledge created in the process of social exchange. (Crotty, 1998, pp. 57-58)

Combined with the work of educationalist Dewey (1910), situated between pragmatism (which measures and evaluates learning against practice) and constructivism, *social constructivism*:

> [O]ffer[s] rich alternatives for understanding the processes of learning and education, knowledge and truth, and experience and culture … [presenting] a perspective on the world of action and interaction, especially related to participation in democratic institutions. (Hickman, Neubert, & Reich, 2009, p. vii).

"The social constructionist perspective opens up the possibility to look at the interaction between the individual construction and the culture within which it exists" (Crotty, 1998, p. 63). Broadly, the exogenic world-centred perspective of theory and practice is constructionism as an epistemology, and the endogenic, mind centred perspective that describes the actions people take is constructivism (Richards, 1995).

Social constructivism, as an approach to teaching and learning, therefore applies pedagogical practice using culture, language, and context to make meaning of learning (Woo & Reeves, 2007). The constructivist developmental processes in a GLE are feedback mechanisms. When feedback is intrinsic to the active learning, that is, it is the consequence of a choice relative to the intended goal, the learner can resolve their learning without extrinsic teacher intervention (Laurillard, 2002, 2016). The nature of the GLE requires the learner to interface with the digital platform via a personal device, self-paced, and with immediate feedback according to the algorithm of the GLE programme (Laurillard, 2016). In her study of educational maths apps, Laurillard (2016, p. 37) identified that the use of algorithms alone does not foster conceptual learning:

i) the task is to answer a multiple-choice question, which (a) motivates guessing, and (b) does not invite learners to think about wrong answers;

ii) goals and feedback are extrinsic to the actions so do not develop the concept;

iii) the tasks are randomly generated and are not adaptive to the learner's current performance and needs (Laurillard & Baajour, 2009);

iv) they have graphics, animations, sounds, and storylines, that have no intrinsic integration with the conceptual content, and are simply distracting (Habgood & Ainsworth, 2011).

Laurillard's alternative app contrasted by: constructively aligning actions to achieve goals by matching learning activities to assessment tasks; ensuring goals are transparent and understandable to learners; learners are capable of performing the actions necessary to achieve the goals; feedback links actions to goals; and the pace and difficulty level adapts to the learner's performance (Laurillard, 2016).

Lameras et al. (2015) advanced a social constructivist approach to expand gamification from a single concept to an entire course to create an engaging, immersive, transferrable student learning experience, by establishing and maintaining a sound technological infrastructure in which GLE sessions occur. This signalled a change in the direction of thought from placing gamification into the curriculum, to curriculum as gamification (Marklund & Taylor, 2016), by starting from the game and building the curriculum, and with learning activities as situated action. Hence the concept of *gamified curriculum*. This is a subtle nuance not unlike the difference between *assessment of learning* (summative assessment at the end of learning) versus *assessment as learning* (formative assessment throughout the whole learning process) (Earl, 2013; Herrington & Oliver, 2000). With this in mind, we need to first examine the two terms that make up a *gamified curriculum* as individual concepts on their own, and then combine them to understand the distinct third construct that is created.

2.4.12.1 Gamification

Gamification focuses on how games can be used in the teaching and learning, and strategies to facilitate learning in game-based frameworks. In this way the experience of play is perceived more than learning (Connelly et al., 2009) and is the mechanism for unconscious learning without any specified or acknowledged goal (Erhel & Jamet, 2013). Evaluation of effective learning using games after mapping games elements to learning (Hartfield, 2010; Hirumi et al., 2010) and the subsequent building of taxonomies for games and learning attributes (Arnab et al., 2013; Bedwell et al., 2012; Connolly et al., 2009) have begun to create a dialect and space for a *gamified curriculum theory*: "where the traditional assessment and marking system is dispensed with and all student activity allows for the accumulation of experience points" (de Byl, 2012, p. 3).

2.4.12.2 Curriculum

Among the definitions of curriculum, Hicks (2007) insisted that it is the what, when, how, and why of learning and teaching, while Kiley (1994) stated that it refers to planned learning opportunities offered, and experiences encountered by learners. Musoro (2007) told us it is progressively more challenging learning experiences designed to support students in demonstrating program level outcomes. A programmatic approach designs a course to meet a need (Barratt, 2010). A course evaluation approach focuses on the student experience to inform course design, where the creation of a certain learning environment will predict learning outcomes (Steyn et al., 2019; Tucker, 2013)

Biggs and Tang (2007, 2011) define curriculum as learning outcomes, assessments, and teaching and learning activities. Biggs' (2003) principle of constructive (build and develop) alignment (teaching, learning, and assessment) as a system of interrelated, sequential items for outcomes-based curriculum design, gives us a robust repeatable model; a model derived from both the teaching and learning perspective, and designed with the end in mind. Tasker (2012) extended this model with his cognitive learning concept, where constructivism meets reflection. Thus, good curriculum design is a transitional sequence of teaching and learning activities supported by linked items of assessment (Biggs & Tang, 2011). This is constructive alignment (Biggs, 2003) where learners construct meaning via cognitive psychology, and teachers deliberately align learning outcomes with learning activities measured by appropriate assessment and feedback. In summary, research has indicated a move from gamification into curriculum, to curriculum as gamification, using design features that lead to learning and support gamification.

2.5 Learning design for student engagement using gamified learning

Learning using gamified curricula has become more commonplace as a method to evoke engagement (Crisp, 2014). At the intersection of *gamification of learning* and *learning design for student engagement*, for GLEs to have practical implications and outcomes, design requires attention to three areas (Dominguez et al., 2013):

- The cognitive area: design of a hierarchical tree to limit the gamification course topics and optional exercises structure, comprised of topics, optional exercises (challenges), specific tasks in each challenge (trophies or activities), and specific steps (levels) with detailed description (narrative and hints).

- The emotional area: inclusion of rewards and achievements (formative and summative assessment items and grading).

- The social area: promote student interaction (discussion boards, forums, in game communication to be incorporated into the research experiment) which can be cooperative, competitive, social, or a combination of these.

Some research has addressed these three areas by comparing recognised approaches to educational games and social networking with more novel pedagogies of gamification and social gamification. de-Marcos et al. (2016) compared formal and informal learning in GLEs. They looked at learner results within an educational game, a gamification plugin, a social networking website, and a social gamification website. They found that the integration of a game into a learning experience improved learner performance "if the learning modules are supported by the game" and conversely when the educational game was not supported by the learning modules "the benefits in terms of learning performance disappeared" (de-Marcos et al., 2016, p. 111).

Considering gamification as motivational design that combines usability with learning, Damsa (2016) proposed that game principles are transferrable to real life situations stimulating motivation towards a desired goal or a change in behaviour to achieve an alternate outcome. The components of the GLE design include not just the game mechanics, game dynamics or structure, and game elements or activities, but also game aesthetics and game thinking (Damsa, 2016). In order to motivate the learner to seek alternate paths, participate in both stipulated and additional activities, and solve problems with the GLE, there must also be an ease of use, actual and perceived (Venkatesh & Davis, 2000), a clear purpose for the commitment to the GLE, and alignment of the content with the learning outcomes (Biggs, 2003; Biggs & Tang, 2011).

Bartle (2009) previously identified four basic characteristics of game players, equivalent to any social system, business environment, or education space:

- socialiser – community minded, team player
- explorer – seeks information and hidden meanings, researches extensively, attention to detail
- achiever – strives to be first in class, sits at the top of the leaderboard, has the best equipment
- killer – the ultimate competitor, win at all costs

Different game genres match the characteristics of different game players, and different genres will best match the discipline or teaching concept being encapsulated in a GLE (de Byl & Brand, 2014). Within games different roles will appeal to different learners as identified by Bartle (2009), and different roles will require different activities. For example, in an undergraduate informatics gamified course Davis et al. (2018) investigated the effects of student characteristics on learning and engagement. Students chose different course activities which all counted towards an accumulation of points which were shown on a leadership board and used to calculate grades. Davis et al. (2018) found that “nongamers expressed somewhat less motivation to do well in the course than frequent gamers” (p. 492) but otherwise all students were equally engaged. “With respect to the gamified activities that students found most engaging, opportunities for collaboration emerged as considerably more popular than competition with other students” (p. 500).

2.5.1 Educational technology

This study now examines how technology affords the gamification curriculum, the use of *educational technology*, and other emerging theories of the *digital learning environment* (McKenzie & Parker, 2011; Schedlitzki et al., 2011).

Many studies have focussed on the technology of software in the accounting industry. Traversing the timeline, Boyce (1999) described the technology bandwagon, “a psychological phenomenon where [educationalists] do something mostly because others are doing it, often ignoring their personal principles or underlying evidence” (Herbert, 2017). Matzen and Edmonds (2007) agreed with the need but were concerned with how computer literacy could be developed. Similarly, Koehler and Mishra (2005) described the educators’ lack of technological, pedagogical, content knowledge (TPCK) and how these could be advanced through group design. Although referring to language learning, Plass et al. (2003), and Diao and Sweller (2007) agreed that educationalists are quick to adopt available multimedia tools, but maybe not adapt them. Both demonstrated that providing authentic environments can lead to knowledge retention, but not necessarily the development of higher order thinking skills (Kaider et al., 2017; Oliver, 2015). Rather, these require educators to engage learners' interest through informative questioning and discussion, attending to diverse psychological attributes and learning processes.

Providing computer skills was regarded by O'Connell et al. (2008) to be secondary to the aim of effective teaching, where a "traditional emphasis of developing technician accounting skills rather than understanding how accounting systems enhance decision making, makes accounting less attractive" (p. 49). Their approach was for the development of accounting knowledge within an information technology environment where conceptual knowledge was valued over technical skill improvement:

> Most studies concentrate on technical skills, for example financial modelling, for industry needs. Integration [of computer skills] into the accounting curriculum should be to develop and reinforce understanding of concepts. (p. 50)

Studies that examine the effect of technology on learning outcomes are inconclusive and indicative of the general learning literature across disciplines (Richardson & Tan, 2005). Richardson and Tan (2005) offered an explanation for this as the use of a tool for the sake of introducing technology, as in Boyce's (1999) technology bandwagon, where learning or curriculum is not embedded into the tool, but rather the tool is added into the curriculum. Boyce (1999) held that the result of not making the technology tool part of the curriculum, was a disconnect in curriculum design where the resource does not facilitate learning to achieve assessable learning outcomes.

Some studies did in fact approach the addition of technology into the curriculum as an integration, not as an add-on, and gave consideration to the question of using it as an effective teaching tool to enhance learning. Abraham et al. (2001) reported benefits to introductory accounting in terms of performance, effort, and attitude. While directly attributable changes to performance and effort were unclear in their sample, students' attitude to accounting consistently increased, and they postulated that this might contribute to reducing attrition in accounting majors between introductory and advanced courses.

2.5.2 Digital learning environment

While technology has enabled the digital learning environment, education designers cannot assume students know how to handle technology for learning just because they use it in everyday life (Kennedy et al., 2009; Skiba & Barton, 2006). As discussed in relation to learner style preferences in digital pedagogy (Section 2.4.3), education designers must also be mindful that individual gaming literacy, skills, and competencies will vary within student cohorts (Marklund & Taylor, 2016). Marklund and Taylor (2016, p. 134) cautioned against "group[ing] manageable batches of students with assumed proficiency" because the student population of *digital natives* (Prensky, 2001) will reflect the general population and exhibit the full bell curve range of competency. In a discussion about educational games, the attribution of mastery is not a given related to age and/or demography. Taylor and Newton (2012) in their study of blended leaning – the use of online digital resources with traditional lecture format – found that "students' abilities and agilities in a technology enabled environment were sometimes overestimated" (p. 56), with students being surprised at the levels of competencies they were expected to have. Krause et al. (2009) advocated for a support framework for students that included assistance with both technology literacy and usage. While some students will have a high level of operational knowledge and efficiency, many will need tutoring (in class or via online demonstration) in how to work with the mechanics of an educational product to enable them to participate and achieve desired learning outcomes.

As examined in the discussion of learner preferences in digital pedagogy (Section 2.4.3.2), perceived use, usefulness, and ease of use in the models for mobile learning (m-learning) (Lin et al., 2013), technology acceptance model, and universal theory of acceptance and use of technology (Venkatesh & Davis, 2000; Venkatesh et al., 2003) (discussed in Section 2.4.3.2, Learner preferences in digital pedagogy), affect adoption of technology as part of learning. Further, performance expectancy using the digital learning platform and effort expectancy involved to understand the user interface, can act as barriers to learner use, and therefore also affect adoption. Ashton-Hay et al. (2016) found this to be particularly so in their investigation into capturing the international student voice regarding transitioning experiences to Australian higher education institutions in three regional universities. They found a general "lack of readiness and familiarity", confusion because technology for learning and teaching was not widely used in their country of origin, resultant panic from a lack of awareness and understanding, and uncertainty with how to engage with learning management systems. They concluded that, "although students may be adept at using some technologies, the ways to use technology for learning and the ways to engage with learning through technology were less familiar" (p. A-11).

Throughout history *technology* has evolved: stone tablets to parchment; calligraphy to the printing press; books to ebooks; and, slates back to *tablets*. Commercially available learning management software even adopts names once associated with physical learning and play artefacts (e.g. *Blackboard*, *Sandpit, PebblePad*) and gives them enhanced, new definitions in terms of digital learning. The old school slate could only represent the student's interpretation of the teacher's delivered content; static, expert-produced resource (Hockly, 2013). The tablet device offers access to the collective wealth of information; a "more creative, consumer-driven space" (Hockly, 2013, p. 84). This immersion in the digital learning environment changes the teacher's role from purely directive to more passive observer, guiding not interrupting the learner's exploratory learning experience (Bellotti et al., 2012; Thomas & Seely Brown, 2011).

Pedagogic design provides guidance for game-based learning activities and associated learning resources, and at the same time game design informs the GLE. Attributes unique to gaming are broadly thought of as the rules (Lameras et al., 2015), but research on extended game-play by Hooper (2017) investigated how players work around and beyond the rules or game mechanics to create new experiences the original game designers had not intended. In games this may be extending the jumping capacity of an avatar. In a gamified curriculum, extended play could manifest in self-directed exploratory learning and solutions, different to or beyond what the teacher/designer intended in the learning outcomes.

The rules then provide the context for the learning, the guideposts and maybe the constraints (Charsky, 2010). The gamification structure consists of both rules and challenges to be met within the confines of those rules through *emergence* and *progression* (Lameras et al., 2015). Emergence is used here as the collective game structure, or a set of specified rules in combinations for game variations, that the players design strategies to manage (e.g., strategy, action, and board games). Progression is where the player performs designed tasks to complete the game. In storyteller games, it is where a storyteller or narrator sets the ground and setting for the story, delivering descriptive information and plot points as the story proceeds (Bopp, 2007).

Rapid change of the digital learning environment characterises the greater domain of e-learning, with learners and educators affected and socialised in the ubiquitous technological developments of society (Bozkurt, 2020). Simon (2016) posited that e-learning as an evolving field, revealed technology development linked to learning theories. Although Simon's research was in computer assisted language learning, the underlying theoretical foundations of e-learning and learning descriptions are well established for e-learning as an inter-disciplinary field. He identified these as: behaviourism as a restrictive or inward learning description; cognitivism as open or outward learning approach; and constructivism where behaviourism and cognitivism are integrated (Simon, 2016). The development of e-learning has been most influenced by the open access to knowledge and the cognitive socialising effect of a digital environment, that allows and encourages creativity and interactivity (Bozkurt, 2020). Learners can construct and design their own learning experiences on multi-user platforms in virtual learning communities.

While creating these personalised learning experiences, learning designers must not lose sight of the end game – learning objectives and their associated learning outcomes. The next sections discuss *formative assessment*, and *game-based assessment* within the GLE.

2.5.3 Formative assessment as game-based assessment

In research on assessment reform in higher education for the Australian Learning and Teaching Council, Boud and Associates (2010) proposed that assessment has most effect when it is formative, and "feedback is used to actively improve student learning; feedback is informative and supportive and facilitates a positive attitude to further learning; students seek and use timely feedback to improve the quality of their learning and work; students regularly receive specific information, not just marks and grades, about how to improve the quality of their work".

A common theme of gamification research holds that games need to be goal-directed and competitive, and designed with a rules' framework requiring interesting choices that are mentally challenging and strategic, not just skill-oriented (Lameras et al., 2005). This is to enable both learners and teachers to monitor progress (grading) via game attributes. Levelling up equals learning enhancement and performance improvement delivered via experiential learning and task completion (Bedwell et al., 2012, Lameras et al., 2005).

Salmon's (2004) 5-step model of e-moderating (Figure 8) supports the formative development process for learning online, and concurrently explains the interactivity skills needed by evaluators. e-Moderating is where a teacher "promotes human interaction and communication through the modelling, conveying and building of knowledge and skills … within an online environment designed for interaction and collaboration" (https://www.gillysalmon.com/e-moderating.html). Salmon matched the educator's ability to facilitate adaptive learning through the interactive use of hard and soft scaffolds, to achieve learning objectives. Each learning level of Salmon's (2004) model – access and motivation, online socialisation, information exchange, knowledge construction, and development – is underpinned by interactive e-moderation and the technical support that enables it.

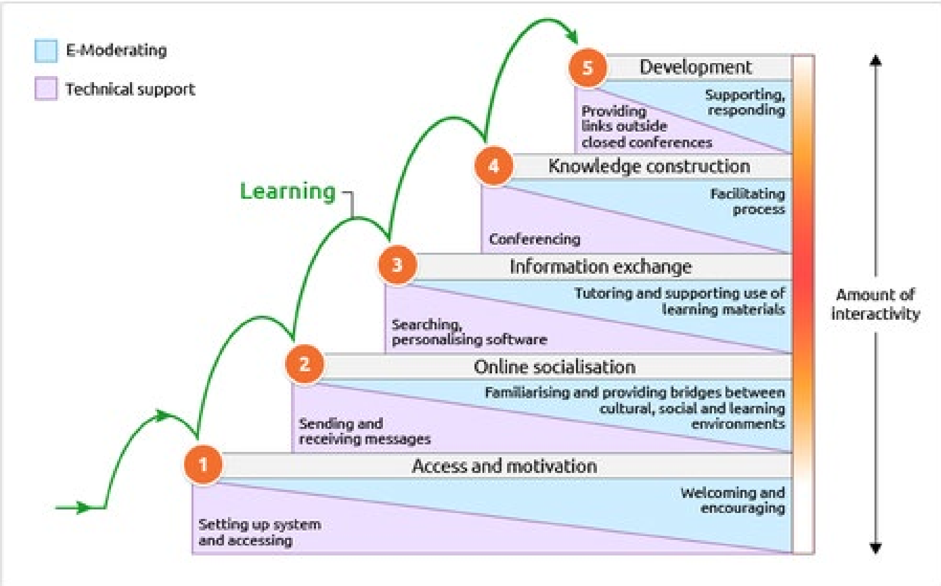


Figure 8 **5-step model of e-moderating (Salmon, 2004)**

In his analysis of students using the Blackboard learning management system for assessment in faculties of education and science, engineering, and technology Baleni (2015) confirmed Salmon's (2004) e-moderating interactivity, asserting:

> [E]ffective online formative assessment can nurture a student and assessment centred focus through formative feedback and enrich student commitment with valued learning experiences. Ongoing trustworthy assessment tasks and interactive formative feedback were identified as significant features that will deal with intimidations

> to rationality and trustworthiness within the milieu of online formative assessment. (Baleni, 2015, p. 228)

Other research by Wichadee and Pattanapichet (2018) used a simple free online digital quiz game "Kahoot" for an experimental study of formative game-based assessment of learning in an English language college class. They found the digital group or learners performed significantly better and expressed higher motivation than the non-digital group of learners.

In a recent examination of the effectiveness of usage of online resources, Massoudi et al. (2017) found a significant positive relationship between formative assessment delivered online and conceptually challenging concepts in accounting education. However, they went on to state that while the availability and active use of a digital resource was precursor to improved assessment performance, "other factors such as prior academic performance, tutorial participation, and demographics, including gender and attending university as an international student" (p. 1) were linked to better performance. Therefore, they recommended the assessment of a range of questions within the resource rather than an aggregate score.

Specifically addressing game-based assessment, Eseryel et al. (2012) have proposed an interactive design and assessment framework to promote (engagement) motivation (self-efficacy) and complex problem-solving skills. (performance).

> [I]n order to design an educational game we need to pay special attention to the functionality, game play, referentially, social, and pedagogical issues [to] target learners' motivation and complex problem-solving skills, we take the explicit interactions between players and games as a persistent cycle of making choices through the game play. (p. 260)

Eseryel et al. (2012) held that this interactivity of design and assessment was a function of three levels: (1) interface, the physical experience and use of the game; (2) narrative, the cognitive immersion in the story; and (3) social, the collaborative opportunities with other players. Of these, the functional interactivity of play action at the interface is the essence of the game, allowing for suspension of disbelief (Csikszentmihalyi, 2008). The player is then immersed in the first-person perspective of the plot driven narrative, which motivates them to continue through until the end of the game and the integrated game-based assessment (see Section 2.4.1.2, Motivation). Although the human social or collaborative opportunities may not be present in an individual learner GLE, social interactivity (for the discussion see Section 2.4.12, Constructive learning) between the individual learner and the culture of the learning game transpires (Crotty, 1998). Constructive learning none the less occurs as the learner interacts with the teacher designed content and story, game artefacts, and non-player characters (e.g., the narrator) within the game. In summary, researchers have found that formative assessment opportunities within learning games contribute to fulfilment of learning objectives and their associated learning outcomes.

2.6 Threshold concepts

This section examines threshold concepts, specifically in the problem domain of accounting and finance and the *technical threshold concept* of the *time value of money* (TVM) (Dempsey, 2003). The underlying theories of *cognitive load theory* and *authentic learning* are discussed in terms of how they work to inform the pedagogy of the threshold concept.

The resolution of troublesome knowledge challenges and forces conceptual thinking via the portal of a threshold concept, transforming it into something to be tackled not avoided, building confidence in the ability to resolve and progress, and the self-efficacy to deal with future elevated challenges (Meyer & Land, 2006; Weil & McGuigan, 2010). Lucas and Mladenovic (2009, p. 148) also describe "a threshold concept [being] something akin to a portal, opening up a transformed internal view of subject matter, subject landscape, or even world view". The core concepts of learning objectives often represent such troublesome knowledge, requiring a new way of thinking, understanding, interpreting, or viewing, something previously inaccessible, but key for progression of understanding. The comprehending of threshold concepts may a require shift in the learner's identity, challenging what they held to be true. It may require them to access uncertainty, or apply a different definition to something erstwhile familiar, in a different context (Meyer & Land, 2006). The learner is in a transitional period of not completely knowing but knowing differently than before. Meyer and Land (2003) describe the passage from one level of understanding to another as being in a state of liminality; that is, within but not yet at the threshold of new knowledge. This is equivalent in cognitive psychological terms to being in Vygotsky's (1978) Zone of Proximal Development (see Section 2.3.4 for full discussion): the threshold where the learner is not yet competent and able to complete a task independently. Both Lucas and Mladenovic (2007) and Weil and McGuigan (2010) identify this connection and state that "theoretical development of threshold concepts should draw on other fields of research, such as cognitive psychology" (Weil & McGuigan, 2010).

2.6.1 Technical threshold concepts in accounting and finance education

In accounting and finance education, as in other disciplines, the threshold concepts are part of the compulsory core and are required to be acquired early on to enable students to build more complex knowledge in advanced units (Hancock et al, 2016). Factors at play, including wide student demographic and mass higher education participation (Dean et al, 2020; Freeman et al., 2008), predispose a formulaic procedural approach to teaching to meet professional associations' accreditation requirements (van Mourik & Wilkin, 2019). As a result, the teaching of threshold accounting concepts regresses to a path of least resistance, or one-size-fits-all model, of using dense textbooks filled with worked examples (Dempsey, 2003; Dean et al., 2020). These can fail to address the theoretical underpinnings of the concepts, or changing and contentious issues, discovered and unpacked through discussion and critical analysis (Lucas & Mladenovic, 2009). This entrenched curriculum can create an impediment to learning. Rather than teaching in a way to embed the characteristics of threshold concepts, it only addresses the procedures to be learned and followed under defined conditions (Boyce et al., 2019).

In addition to the problems identified in the procedural approach, dissonance is created in the learning and teaching of accounting and finance technical threshold concepts owing to the pre-existing schema that contrasting lived experiences and world views of students and lecturers (and between lecturers) (Cousin, 2006; Lucas & Meyer, 2005; Lucas & Mladenovic, 2009;) bring to the learning activity. Lucas and Mladenovic (2009) further differentiate conception from concept, defining conception as the organising structure or framework, within which key threshold concepts and learning objectives sit. How these concepts are arranged, is determined from the teacher's pre-existing schema; their perspective. Lucas and Mladenovic found that, "lecturers perceived accounting in two main ways: first, as a micro activity which involved the preparation of financial statements (preparer perspective) and second, as macro activity which involved the role and use of accounting information in a wider context (user perspective)" (2009, p. 149). They went on to point out that, "although the macro activity scaffolds the conceptual structure, teachers often eschew this aspect in an attempt to dispel inhibitors of perceived negative learner perceptions" (2009, p 149), resulting in the teaching of techniques, and still struggling to engage learners without contextualising content. Learners identify concepts and apply processes, but fail to use the higher order thinking skills by not analysing, evaluating, or questioning what they are learning (Bloom, 1956). Willingness to problematise issues is not developed (Lucas & Mladenovic, 2009). From the learner's perspective there is not yet any acceptance that different terms will have different meanings in different contexts (e.g., cash, profit, and depreciation) (Lucas & Mladenovic, 2007). The student does not recognise that uncertainty and subjectivity exist in accounting, and that it is a non-lineal process.

Although accounting has a theoretical base, involving complex applications and processes, it is situated in the real world. The practice of accounting requires understanding of theory and process, and application of threshold concepts to make judgements, interpretations, and conduct analysis (Carlon et al., 2018). Addressing barriers to engagement and motivation in teaching accounting threshold concepts means aligning teaching environment (learning objectives, curriculum, and assessment), discussing preconceptions, and comparing lecturer and student views, in the context of the greater community, that is with reference to politics, literature, and social issues (Cousin, 2006; Lucas & Meyer, 2005).

When the classroom experience exists as detached explanations focussing on discrete components of financial statements, or global explanations of financial reports without the surrounding framework to situate this new information, (Lucas & Mladenovic, 2009) the learner has no opportunity for phenomenographic understanding. There is no opportunity to engage in authentic exercises or discussion. Such qualitative discussion occurs when learners are pushed to examine the authorised conceptions from text books versus their every day, tacit, or intuitive understandings of threshold concepts, and alternate views based on their own experiences. It is natural for students to hold on to long-held perceptions and understandings (Lucas & Mladenovic, 2009). Transformation is possible when these are allowed as discussion points, for example, comparing and contrasting the decision making and risk profiling of individuals versus businesses. The scaling up of understanding and contextual appreciation (Linder, 1993) discounts troublesome uncertainty.

Biggs and Collis' (1982) structure of the observed learning outcome (SOLO) taxonomy provides a means of "classifying learning outcomes in terms of their complexity, enabling [assessment] of students' work in terms of … quality not of how many bits of this and of that they have got right" (Biggs, n.d.). SOLO (Biggs & Collis, 1982) describes demonstrated connections within the demonstrated knowledge of the concept area and to other areas of knowledge as expressed and assessed in an assessment piece. Learning activities that develop abilities to do increasingly complex operations with knowledge and express increasingly complex conceptions (Sweller et al., 1998) may lead a learner to achieve *threshold conceptual clarity* (Lucas & Mladenovic, 2006).

This allows teachers to identify misconceptions and/or establish whether learners have reached higher levels of reasoning and can demonstrate mastery of concept allowing movement to the next threshold or level.

Integral to the description of a threshold concept is its role in the interrelatedness of organising principles and subjectivity (Lucas et al., 2007). A key part of threshold concepts' learning in accounting education is the recognition of the interrelatedness of aspects of a concept within the regulated accounting standards and framework (Magdziarz et al., 2014). This is "demonstrated when a student engages in a mode of reasoning where techniques are explicitly seen as an attempt to put organising principles into practice" (Lucas & Mladenovic, 2009, p. 153). A technical threshold concept is a particular type of threshold concept, where there is an accepted way of doing something; in mathematics or calculus for instance, a rule or a formula (Scheja & Pettersson, 2010). For example, the learner who has grasped the threshold concept of the accounting equation can see the effects of changes in assets and liabilities, and how these in turn impact on equity.

2.6.2 Cognitive load theory

Research has shown how cognitive load theory can inform the pedagogy of threshold concepts. Developed by Sweller (1988) through his research in problem solving, cognitive load theory holds that working memory (from Baddeley and Hitch's [1974] model of working human memory), has finite cognitive capacity. Cognitive load in learners comprises of three distinct types (Sweller et al., 1998): (1) intrinsic load, the cognitive load from the elements of curriculum content; (2) extraneous load, the unnecessary load placed on working memory because of the instructional method being used; and (3) germane load, where "intrinsic cognitive load due to element interactivity and extraneous cognitive load due to instructional design are additive" (Sweller et al., 1998, p. 262) and impact on the learner's ability to comprehend and develop schema (Mostyn, 2012).

Within an education setting, if a learning task requires too much capacity, learning will be hampered (de Jong, 2010). Mostyn (2012) used cognitive load theory to examine how accounting teaching and learning theory might meet, and to understand and incorporate technology into curriculum. He acknowledged that introductory accounting is a core requirement in all business courses, and therefore teaching must cater to a wide range of learners; students with process driven, lineal thinking, as well as creative, inquiring, and oppositional learners.

Applied to learning, cognitive load theory allows for identification of how learning occurs for the specific functional elements of data, or content, processing. Cognitive load theory examines the types and limits of memory used (Chandler & Sweller, 1991; Cooper, 1998; Sweller et al., 1998). Optimising total cognitive load results in improved learning efficiency with less stress. Using cognitive load theory, Mostyn (2012) showed that procedural efficiency, not motivational methods, was more efficient for novice learners in his accounting case study. He proposed the application of cognitive load theory to introductory accounting starting with optimising intrinsic load (Sweller, 1988). In this case the teacher exercises control over the complexity of content and offers supplementary material. This is carried out via the chunking principle (Miller, 1956), which involves separating and sequencing the interactive elements of a topic to deal with diverse learners with various base level knowledge and schema progression. Attention is paid to reduce the extraneous load of supplemental materials, using worked examples (Sithole & Abeysekera, 2017) as opposed to multiple instances of problem-solving tasks. The design and presentation of the educational content is considered and formatted using basic user-interface techniques for ease of assimilation of screen-based information (https://www.interaction-design.org/), including vignettes, white space, consistent formatting, reader friendly text, and icons.

Specifically, with an accounting and finance technical threshold concept, Sithole and Abeysekera (2017), in their study of accounting students at one university, found that learners conventionally need to "[split] attention among various sources in order to understand and use the instructional materials provided" (p. 10) to embed the concept into their schema of knowledge (Mostyn, 2012). That is, when the split attention effect is part of the instructional design of learning material (Paas & Van Merriënboer, 1993) cognitive load can be reduced, allowing better "physical integration of visual data sources (e.g., combining text and diagrams)" (Chandler & Sweller, 1992, p. 233) or integrating visual and auditory sources (slides and narration) to learn effectively and build or add to a mental model (Paas & Van Merriënboer, 1993). Split attention (Chandler & Sweller, 1992) being one of five different approaches to address the learning of a threshold concept, used by Sithole and Abeysekera (2017) which also included: completion problem effect, modality effect, worked example effect, and expertise reversal effect. Siriwardane (2014) in her research on using case studies, known as *practice sets* in accounting education, further showed how the blending of the passive theory and concept textbook base in a worked example "promot[ed] commercial realism and connect[ed] discipline–based knowledge with practical situations" (p. 97).

2.6.3 Authentic learning

Authentic learning is a pedagogy where meaning is created through exploring, discussing, and constructing concepts and relationships in contexts that involve real-world problems and projects that are relevant to the learner (Herrington & Herrington, 2005). While recognising that it is "impossible to design truly 'authentic' learning experiences, and such attempts [are] the attempt to make learning materials and environments correspond to the real world" Herrington et al. 2003, p. 60) advocated for learning design where "learners [are] persuaded that they are participating in an authentic learning environment" (Herrington et al., 2003, p. 60). The teaching of accounting and finance technical threshold concepts can capitalise on the bounded aspects of authentic learning, where the variables for decision-making are given and contextualised (Barradell, 2013).

Herrington et al. (2003) sought to identify patterns of learner engagement and found that authentic learning environments that produce a positive feeling or congruence for learners, characteristically involved scenario-based role play to solve a problem and create an end product equivalent to a real-world presentation or report, as assessment. They found this engagement, or immersion through suspension of belief, occurred through encouraging and supporting learners, not only to learn, but to self-regulate.

In his examination of adult learning Stein (1998, p. 1) described "the situated learning approach, [where] knowledge and skills are learned in the contexts that reflect how knowledge is obtained and applied in everyday situations. He further stated that "situated learning in the classroom integrates content, context, community, and participation" (p. 1). Authentic learning has also been described as the *participation model* (Patrick et al., 2008) "where students participate in the actual work of a professional community, engaging directly in the target community itself" (p. iv). Authentic learning is one of the key discriminatory elements in Kaider et al.'s (2017) work integrated learning (WIL) authenticity-proximity framework (Figure 9). They expanded on Oliver's (2015) earlier work, where she proposed:

> Two constant and underpinning principles for effectiveness of assessed tasks that relate to employability are: authenticity (how closely a task resembles professional level challenges) and proximity (how closely the context resembles a professional environment). (pp. 61-62)

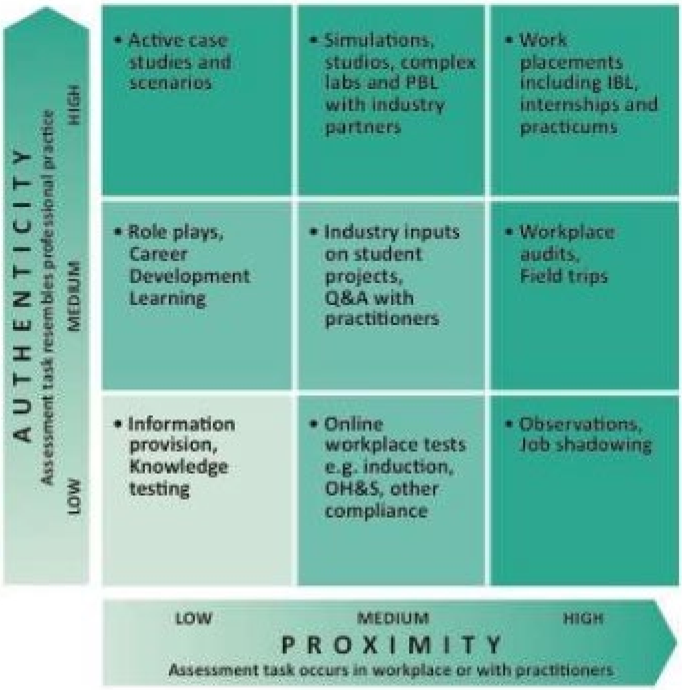


Figure 9 **Expanded authenticity-proximity framework (Kaider et al., 2017)**

2.6.4 The theshold concept: Time value of money (TVM)

This study used the accounting and finance technical threshold concept of TVM. In accounting and finance, the concept of time value of money is critical in developing students' understanding of measurement and valuation of assets and liabilities. Graduates are required to build and demonstrate robust TVM skills to measure and account for assets and liabilities (Stuebs, 2011). Typically, the students' first encounter with TVM occurs in financial accounting requiring long-term debt valuation, next with capital budgeting models in financial and managerial accounting, and then in advanced accounting or corporate finance units using discounting principles. Despite this repeated exposure, students find the concept of TVM challenging, as it is typically taught in discrete units, not situated in a business context (Siriwardane, 2014). Students report a lack of awareness of how theoretical accounting functions of TVM inform management decisions (Kneckel & Rand, 1994). Not surprisingly, teachers find TVM challenging to teach (Dempsey, 2003), rather it requires, "a mathematical orientation to TVM analysis, consistent with an integrated curriculum focus that is increasingly being recognized as essential to holistic learning. (Dempsey, 2003, p. 258)

2.7 Learning design for student engagement in threshold concepts in accounting and finance

At the intersection of *learning design for student engagement* and *threshold concepts*, the existing pedagogy of threshold concepts informs the learning design to be deployed by teachers. There are two accepted methods of teaching the threshold concept TVM: (1) the long-established textbook method of teaching TMV using the traditional pedagogy of tabulated factors; and (2) activity-based student-generated mathematical solutions (Dempsey, 2003). The TVM accounting textbook method invariably consists of a chapter containing the threshold concept, with worked examples, followed by end of chapter problems of the same type. This mechanical problem solving does not support higher order critical thinking skills. Students merely identify the value of a discount factor from coordinates on a table. Dempsey (2003) holds that the use of tables "inherently impedes understanding" (p. 240), and instead advocates the use of a mathematical formula pedagogy.

In contrast to the textbook method for teaching TVM, the student-generated mathematical method involves the use of computerised exponential functions to solve TVM problems. Here students plug given variables into a formula to produce an answer. While efficient, in terms of time and resources, a disadvantage of this method is that students may fail to grasp the underlying math, merely becoming technicians, and therefore be unable to synthesise and/or evaluate more involved problems. However, Dempsey (2003) dismissed critics who preferred the table approach, by citing: calculus concepts and exponential functions as substantive and adequate math prerequisites; redundancy of textbook appendices; and disinclination to change from familiar teaching methods. His experimental study suggested that the mathematical approach was "more efficient, more effective, and more likely to be the preferred method by students [and] that the two approaches might actually *complement* each other" (p. 258).

In addition to research on the two primary methods for teaching TVM, research has also been conducted into learning success. TVM is typically taught in introductory accounting subjects and analyses of student performance in introductory accounting subjects consistently cite high failure rates in the range of 35 to 45% (e.g., Doran et al., 1991; Kealey et al., 2005, Muller et al, 2007). Some research has focused on measures of academic aptitude as a predictor of success. Eskew and Faley (1988) found that while aptitude and effort accounted for over half of the variance of student performance in first year college-level financial accounting, work experience (not previous performance) was also a significant determinant. Gracia and Jenkins (2002) explored student performance from this "experiential perspective, recognising the complexity and subjectivity of academic performance" (p. 93). They identified a number of contributing factors: mismatched perceptions, teacher to learner, of reasons underlying the choice of course of study; the importance of the role of the tutor; the tutor expectations gap; the level of control and personal responsibility for learning; and patterns of participation. McGuigan and Weil (2011, p. 15) examined first-year students' experiences in an introductory accounting course and also argued that "students' preconceptions of the accounting discipline form a major preconceptual threshold in their learning". These research studies into aptitudes supporting success have shown that there are other factors at play.

In contrast to the research into the relationship between aptitudes or work history on success in accounting, other research has investigated the influence of students' approaches to, and beliefs about, learning. Beatson et al., (2019) examined self-efficacy beliefs and prior performance as determinant variables for accounting academic success, and found self-efficacy to be "above and beyond the influence of high school experience with accounting or the fact that the student had unsuccessfully taken the course previously" (p. 17). Duff (2004) sought to understand how prior performance affected students' approaches to learning and their subsequent performance and progression in higher education. He categorised students as *effective learners* and *ineffective learners*. This is in line with Biggs' (1987) 3Ps model of student learning processes, where the "approach to learning is affected by perceptions of requirements of the learning task … perceptions of context of learning [teaching methods, curriculum, and assessment] … and their orientation to learning … and is determined by their prior educational experience and the learning context" (Duff, 2004, p. 412). Effective learners were found to have a deep approach to learning – "intrinsic: study to actualize interest and competence in particular academic subjects" – and conversely ineffective learners were more inclined to a surface learning approach – "instrumental: main purpose is to meet requirements minimally … a balance between working too hard and failing" – (Biggs, 1987, p. 11).

Using computerised business simulations in accounting education, Marriott (2004) identified the challenge of *instrumentality*; that is, experience and context, or relatedness, as a determinant for learner motivation and success. Learners are "motivated to study accounting not because of some inherent love, or proven ability, for the subject, but for vocational reasons linked to future extrinsic reward" (Marriott, 2004, p. 55). Instrumentality tends to lead to the adoption of surface learning practices. However, this absence of experience can result in the adoption of abstract conceptualisation to build a schema for constructing learning, and these learners preferring theoretical assessment. Marriott (2004) used a computer simulation to address these challenges and "present opportunities for students to develop algorithmic thinking" (p. 55).

Further discussion of the types of experiences that might prepare students for success in accounting and finance subjects, other research has reviewed the determinants of learner motivation and success, such as sufficient preparation in terms of prerequisites. Kealey et al. (2005) found more than one third of medium to large American universities had no prerequisites, and of those that did algebra was the most common prerequisite. A search of Australian universities revealed a similar situation. However, given the high failure rate of students in introductory accounting subjects, Kealey et.al. (2005) suggested that "success in principles of accounting may require a more sophisticated level of reasoning than that required for … algebra". Their research found that "critical thinking skills are significantly associated with performance in principles of accounting" (p. 34).

Both the Australian professional accounting registration bodies (CPA Australia and CAANZ) require graduates to be able to demonstrate technical threshold concept knowledge and the critical thinking skills to apply this knowledge. This shows that the professional bodies recognize the importance of critical thinking and skills beyond technical practice. For professional accreditation, CPA Australia (similar for CAANZ) require degrees to provide opportunities for learners to develop skills prescribed in IFAC's International Education Standard 3: Professional Skills and General Education, CPA Australia:

> Intellectual skills enable a professional accountant to solve problems, make decisions and exercise good judgment in complex organisational situations. The required intellectual skills include:
>
> - the ability to locate, obtain, organise and understand information from human, print and electronic sources
> - the capacity for inquiry, research, logical and analytical thinking, powers of reasoning, and critical analysis
> - the ability to identify and solve unstructured problems which may be in unfamiliar settings. (https://www.cpaaustralia.com.au)

With critical thinking identified as a desirable attribute for graduates, accounting educators should be embedding opportunities to develop these skills starting at introductory unit level (Hancock et al., 2016). Both of the traditional TVM pedagogy methods are categorised as passive learning (Biggs, 1987); the students' role being the recipient of knowledge transfer. Active learning methods foster critical thinking (Biggs, 1987), with the ancillary effect of enhancing student motivation and engagement, and encouraging self-learning (Healy & McCutcheon, 2008). Therefore, research into student aptitudes for and approaches to learning can influence learning design for student engagement in threshold concepts in accounting and finance. In particular, designs that support critical thinking align with learner success and professional requirements.

2.8 Gamification of learning for threshold concepts in accounting and finance

At the intersection of *gamification of learning* and *threshold concepts*, there is limited research into gamification of learning in accounting and finance. In their review of digital game-based learning in accounting and business literature, Carenys and Moya (2016) identified three areas of research in the field: preparation to use digital games in education; findings for suitable deployment; and the expectation and evaluation learning outcomes, and distilled a number of areas for further exploration. Specifically, in the preparation stage: (1) "the construction of theoretical and conceptual frameworks that could inform digital game selection"; and (2) "an examination of how digital game-based learning attributes affect engagement, motivation and the attainment of learning outcome" (Carenys & Moya, 2016, p. 645).

van der Heijden (2016) sought to discover how the use of gamification strategies deployed in a social network game in an introductory accounting unit affected learner engagement. He reported on survey responses from students regarding game features having either educational value or being fun, and found a:

> [M]ixed response suggest[ing] that gamification strategies can be complementary and that they may need each other's presence in order to be effective. The features that are fun but have no educational value may be required to carry the aspects that have educational value but are no fun. For example, the opportunity to personalise the [game] allows students to become more attached to [the game], and in doing so it can provide

> some emotional investment from which the educational features benefit. (p. 17)

Silva et al. (2019) in their study of first year accounting and marketing students at one university, investigated how game-based learning could improve flow. They used quiz based digital board games where students played in groups and were randomly presented with topic content questions, with the aim to win by answering all the questions first. Silva et al. (2019, p. 501) “concluded that the educational games that were tested had an effective impact on student’s motivation, flow, concentration, interaction, autonomy attitude, and perceived learning of accounting and marketing areas of knowledge”. However, the application of these games was for the purposes of testing already acquired knowledge not for the acquisition of knowledge itself, and not specifically threshold concepts.

Further, there has not yet been any other research into gamified learning for threshold concepts in any discipline area, indicating that there is a wider gap in published knowledge in the area of gamification of learning for threshold concepts than just for accounting and finance threshold concepts. This provides an opportunity for other researchers to investigate gamification of learning as it relates to their discipline threshold concepts. Potentially, other research might even apply the approach, design, and framework of this research to build and evaluate their eLearningGames.

2.9 Learning design for student engagement using gamification of learning for threshold concepts in accounting and finance

At the junction of all three research areas (Figure 1) – *gamification of learning*, *learning design for student engagement*, and *threshold concepts* - this research has identified a **critical** gap in the literature, where gamified learning design has not been employed for threshold concepts in accounting and finance. Further when considering the overarching question of “Can learning happen in games?” (Arnab et al., 2013; Kapp, 2016), in the gamified learning space learning designers implement various learning games with differing degrees of testing for learning *game effectiveness*, but not concentrated efforts to test for *learning effectiveness*. To address this gap, this research operationalises the blending of course content into a plot driven narrative, via game mechanics and structures, so that learning progress is part of the challenge of the educational game, using *gamification alignment*. This aligning of learning, learner characteristics, and game-based pedagogy and design is done with an instructional game for a GLE. This extends the current research into the area of gamified learning for threshold concepts in accounting and finance. The learning experience is tested within a GLE for the threshold concept of TMV, not only measuring learning outcomes and learners' perceived competence derived from the GLE, but also the learner's experience of learning, which is separated out from the effectiveness of the game attributes. All of these aspects are then combined into a framework as a methodology for evaluation of gamified learning experiences for use by educationalists and education designers.

2.10 Summary

This chapter examined the literature in three areas of research: (1) gamification of learning; (2) learning design for student engagement; and (3) threshold concepts, and described the parallel theories and links between and amongst them. The next chapter, Chapter 3: Theoretical Framework and Methodology, draws the structural and content components of gamification together to produce a framework of *gamification alignment*. It will build a gamification alignment table and a GLE model to develop the research hypothesis and determine the theoretical framework within which to conduct the research. The research methods and conditions for selection will be described.

Chapter 3 – Methodology and Theoretical Framework

3.1 Introduction

Following on from the literature review in the previous chapter, this chapter unites all the strands of research – gamification of learning, learning design for student engagement, and threshold concepts. The structural and content components of gamification are drawn together to produce a framework of *gamification alignment*. The mapping of the language and terminology of research results in a **gamification alignment table**, created for this research. Further this research shows how game types are matching to thinking skills in a descriptive **gamification alignment model**. Together these tools identify a way to examine how gamified learning can be applied to threshold concepts in accounting education. A theoretical framework with constructivism at the core, and encompassed by social constructivism and cognitive learning theory, is encapsulated by Laurillard's (2002) conversational framework. This generalised conversational framework is used for exploring the interactions and relationships that take place in the gamified learning experience (GLE), and how these contribute to learner engagement in, motivation for, and performance of learning. This chapter also provides an overview of the choice of research methods and instruments employed for data collection, measurement of key variables, and data analysis.

3.2 Mapping curriculum language to gaming language

3.2.1 Language of teaching and learning in gamification terms

To develop an evaluation and design framework for the GLE, a gamification alignment table was produced, linking gamification, pedagogy, learning design, and accounting education via congruent meaning of terms for elements and structure. Lameras et al. (2015) identified the need for "establishing a comprehensive and common vocabulary for describing game-based learning concepts and design features" (p. 18). This will enable elucidation of how the

GLE works for both teachers and learners, identification of which game mechanics optimise learning, and the development of a framework to assist learning designers and teachers.

3.2.2 Gamification alignment table

Integrating games into a new culture of learning (Thomas & Seely Brown, 2011) involves coupling game designs, learning principles, student engagement, and learning outcomes, by means of *gamification alignment*: mapping the elements and language of gaming against curriculum components. For this research, to support integrating games into learning, the following alignment of pedagogical and gaming terminology was created (**Table 4: Gamification alignment table**). By equating the terms and beginning to think of how gaming can function in an educational context, learning design of gaming as a curriculum entity can deliver learning synergies through student engagement and motivation (Marklund & Taylor, 2016). The gamification alignment table allows learning designers to readily see that their pedagogical lexicon can be easily transformed into learning games because the attributes of learning resources elements match to existing features of games. Once this connection is made the development of the GLE is less daunting, and more intuitive and obvious.

Table 4 Gamification alignment table developed for this research (Wood, 2019)

Pedagogical Lexicon	**Gaming Lexicon**
Unit/course description	Story
Curriculum	Game map
Learner	Avatar
Learning outcome	Mission
Successful completion of unit/course	Goal
Activity	Challenge
Resources/learning tools	Artefacts
Peers/team based learning	Team
Formative assessment	Lives
Assessment	Quest
Marks	Trophies
Grade	Score
Student ranking	Leaderboard
Extra activities	Side quests
High distinction opportunites	Bonuses
Discussion board	Chat

3.2.3 Learner characteristics in games

de Byl and Brand (2014) cross referenced the pedagogical approaches, control, context, competency, and engagement of Gagne et al. (2005) with Kolb's (1981) and Kolb and Kolb's (2005) learning styles (Table 5), and classified accounting students as *accommodators* who prefer concrete experiential learning. Honey and Mumford (1992) had classified these learners as *activists*. A previous review of the literature on learning style preferences by Wilson and Hill (1994) found accounting students tended to be *pragmatists* preferring learning by active experimentation (Honey & Mumford, 1992). de Byl and Brand (2004) refer to these pragmatic learners as *convergers*. Importantly, both the classification groups of activists or pragmatists/convergers are *active* learners. Wilson and Hill (1994) identified the following motivating pedagogical intersections for accounting students: high control over manipulation of environment in order to test hypotheses; context of relevant real-world problems; competency through mimicking; and engagement via role-playing with others.

Research into pedagogical approaches for different learners has suggested that learners in different disciplines may have different learning styles for games. For example, Egenfeldt-Nielsen et al. (2008) defined a system of four genres based on games' criteria for success: (1) strategy games, (2) adventure games, (3) process-oriented games, and (4) action games. This fits well in the context of games for learning in which action, thinking, and systemic understanding are clear goals aligned with learning characteristics. In addition to identifying a criterion for success, their model also accounts for the typical action a player performs in order to achieve success.

Extending the concept of gamification alignment, it is reasonable to design learning games for particular learning styles. Table 5 presents an extracted summary of de Byl and Brand's (2014) matrix for different student cohorts, their predominant learning characteristics, and game genres, to guide the development of serious games. Their findings locate accounting and finance students within the accommodators learning style. If learning designers use this classification of students as a guide then the design of games can be differentiated to accommodate different learner types and learning styles, however being aware that within the game, students may engage with the content for learning in a variety of ways.

Table 5 Guidelines for development of serious games for specific learning styles (de Byl & Brand, 2014)

Learning Styles	Disciplines	Game Genres
Divergers (Reflectors)	Dramatic Arts History English Philosophy Politics Communications Economics Psychology Anthropology Computer Games Development	Strategy games (featuring world-building real-time strategy, not too pressured)
Assimilators (Theorists)	Geography Economics Mathematics Biochemistry Chemistry Physics	Adventure games (platformers, puzzles, quizzes that reward trial and error)
Convergers (Pragmatists)	Nursing Engineering Computer Science	Process-oriented games (featuring life simulation, role-playing and online social environments)
Accommodators (Activists)	Business Finance Architecture Accounting Law	Action games (following a specific story line but allowing for achievement oriented score ladders)

Note: Darker shaded area indicates accounting and finance students' primary learner style. Lighter shaded area indicates their broader active learner style identified by Wilson and Hill (1994). Honey and Mumford's (1992) classification labels in brackets.

3.2.4 Gamification alignment model

The integration of games into the harmonious part of a bigger ecosystem of learning is the combining of game designs, learning principles, student engagement, and learning outcomes. From the researcher's observation it was apparent that to construct a gamified curriculum requires the cooperation of the content expert, the learning designer, and the digital learner to derive benefit from the synergistic pedagogical practice of using gamification for learning. Drawing on the research and literature from the fields of serious games (Egenfeldt-Nielson et al., 2008; Jones et al., 2014), curriculum theory (Biggs, 1987, 2003; Biggs & Tang, 2011), cognitive learning (Tasker, 2012), learning styles (Felder, 2010, Felder & Silverman, 1988, Kolb, 1981), motivation (e.g., Maslow, 1943; Radoff, 2011; Ryan & Deci, 2000) and engagement (e.g., Barkley, 2010; Coates, 2006; Shulman, 2002), and bringing these together with accounting and finance education, specifically the teaching of threshold concepts in accounting (Lucas & Mladenovic, 2009), this research provides a model for designing and evaluating curriculum as a GLE. This is made possible by using the taxonomy in the **gamification alignment table** (Table 4) and the **gamification alignment model** (also created for this research and shown in Figure 10) together. To develop the gamification alignment model, the researcher began by looking at common game types. To understand the commercial game types currently in use, an inspection of game producers' sites revealed Allen Interactions' taxonomy of gaming (http://www.alleninteractions.com/about). This was then aligned to the thinking skills elucidated in Bloom's taxonomy of learning. The gamification alignment model is then populated with concepts and pedagogical verbs for use by educators and learning designers in planning and designing GLEs.

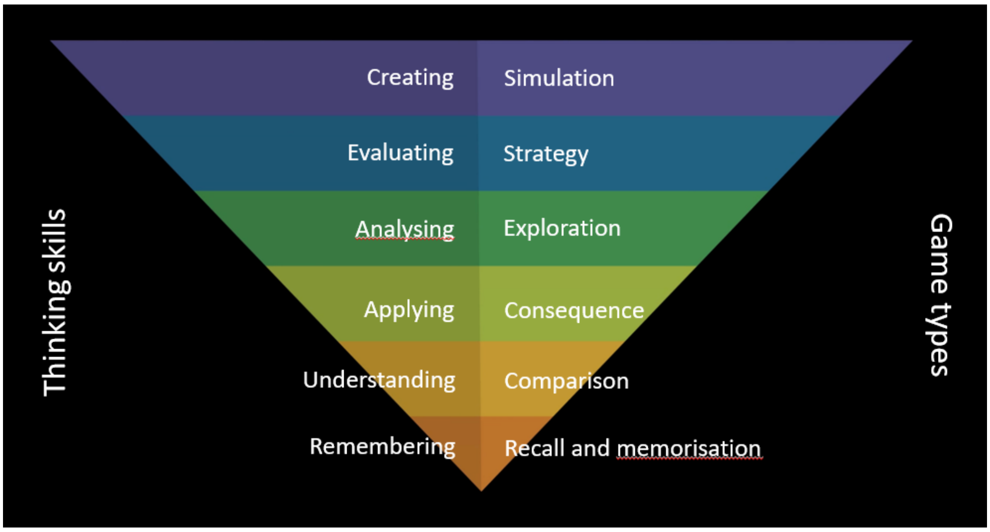


Figure 10 Gamification alignment model developed for this research (Wood, 2019) (Adapted from Allen Interactions http://www.alleninteractions.com/about; Anderson et al., 2001; Bergmann, 2016; Bloom, 1956)

The game types involve different sorts of learning activities, which relate to thinking skills matched to the six levels of knowledge in the cognitive domain (Anderson et al., 2001; Bloom, 1956). Ideally the learning activity prepares the student for success in the assessment, which demonstrates that the student has reached the learning outcome. The six levels were aligned and described as follows:

Bloom's *remembering* level is aligned with games of *recall and memorisation* where students are required to demonstrate memory of already learned facts and concepts by recalling and selecting from presented materials, for example matching terms with definitions.

As in Churches' (2009) digital verbs for digital processes (Figure 5), digital activities within the learning games include searching, highlighting, and bookmarking. The *understanding* level is aligned with *comparison* games, where students demonstrate their understanding of learned facts and concepts by classifying and comparing concepts and ideas, for example choosing the most correct answer from a selection of options. Digital activities performed within these games include tagging, tweeting, and commenting.

The *applying* level matches to games of *consequence*, where students attempt solve problems using acquired knowledge in new scenarios through planning and experimentation, then select from the best outcome. Digital activities in these games include playing through, sharing, and editing.

The *analysing* level aligns with games of *exploration* which require students to dissect game world scenarios and make inferences about possible choices and outcomes. These are games where students can actually explore different options within the game to find the optimal pathway or result. Digital activities within these games include cracking, linking, and hacking.

The *evaluation* level matches to *strategy* games where students need to validate and defend their opinions and choices, making judgements and recommendations based on learned material. These are games where students bring multiple criteria together to prioritise and validate their choices within the learning game. Digital activities within these games include reviewing, posting, and testing.

Lastly, *creating* is aligned with *simulation* games. These are not just games which utilise the game mechanics to create worlds and characters, but the capstone unit games where students compose and construct the whole of game world using multiple sources of information and combinations, to propose, develop, test, and theorise all their previous learning. The digital activities used in these games include programming, animating, and mixing. Examples of these type of games are *Minecraft* and *Fortnite*, where students/players build more sophisticated avatars and cities as they progress through the learning game, demonstrating a synthesis of their accumulated knowledge.

To further illustrate the investment in time and practice spent at each level, the researcher incorporated Bergmann's (2016) flipped learning model, effectively turning Bloom's triangular model upside down. The lower order thinking skills of remembering, understanding, and applying, equate to recall and memory, selection, and consequence games. While these are important foundations for learning, they require and should demand less activity time to embed and master, than higher order thinking skills of analysing, evaluating, and creating, which equate to games of exploration, exploration, and simulation. The construction of the model as an inverted triangle, with more area as the levels build, illustrates the cumulative nature of the thinking skills: each successively higher level builds on and incorporates the level/s below so that at any time during higher level activities, lower levels are still being called upon.

3.3 Theoretical perspective

Constructivist theory informs the design of this research and tests of the hypotheses. Von Glasserfeld (1995) proposes that the theory of constructivism drives empirical enquiry, dictating what observations, research design, experiment, and measurement to employ.

> Constructivism occupies a methodological space characterized by ontological realism and epistemological relativism. [With non-positivist epistemological assumptions, it holds that] rules and principles do not exist independently of our theorizing about them. (Mir & Watson, 2000, p. 1)

Mir and Watson (2000) identified a number of assumptions shared by all constructivists. These include: (a) knowledge is theory driven, (b) theory and practice are fundamentally interlinked, (c) research occurs within a community of scholarship where conversations are created, and (d) constructivist researchers use a variety of methods of inquiry. They further recognised subfields within constructivism, including social constructivism.

This research followed a constructivist epistemology, where the research participant's interactions with the world create truth and meaning; that is, meaning is constructed not discovered as something external to the researcher and participants. This methodology has been adopted for this research because participants construct their own meaning in different ways, and even different to each other from the same phenomenon, potentially leading to multiple and contradictory but equally valid or arguable points of view. This works well in troublesome, threshold concepts, where there are different stakeholders and varied risk profiles (Creswell, 2011).

3.3.1 Inductive and deductive methods

Gray (2014) describes the "combination of inductive with deductive methods as not mutually exclusive" (p. 18). Observation over time using inductive reasoning to generate a theory, leads to interest in other impacts (deductive approach). The resultant formulation of a working hypothesis is then tested with the introduction of an intervention using an experimental approach and a control group, to compare outcome, experience, and impact, and deductions are made as to the meaning and relationships of the resultant data collected.

The choice of a combination of inductive and deductive methods for this research is supported because:

i) Available information/research in the field of accounting and finance education is limited, and in the form of descriptive and ad hoc evaluative analysis of observed discrete applications of GLEs.

ii) The observations of the applications of GLEs is largely qualitatively analysed and not quantitatively measured for larger groups, to see what other relationships and results occur from the intercession of GLEs. This is notably absent in accounting and finance units.

iii) The application of a generic set of principles and practice will be developed for design and evaluation for a replicable framework both within similar degrees and across schools and disciplines.

3.3.2 Exploratory, interpretative, and explanatory research studies

Social researchers use exploratory and descriptive studies to review literature and conduct focus groups (Maxwell, 1996; Robson 2002), to design and test frameworks, and then conduct data analysis on experimental findings. With the addition of interpretive studies, researchers "seek to explore … experiences and … perspectives of these experiences" (Gray, 2014, p. 37).

The theoretical perspective of interpretivism looks for "culturally derived and historically situated interpretations of the social life-world" (Crotty, 1998, p. 67) and by extension, the social enterprise of learning (Dewey, 1910). Akin to constructivism, interpretivism acknowledges the role of the individual's social construct – their actions and values – in the classification of schemas (Gray, 2014, p. 23). The interpretative perspective is appropriate for this research because participants construct their individual learning through learning activities and experiences, in a game life-world.

3.3.3 Constructivism

Constructivism has its roots in Vygotsky's (1962) views on learning and continues to guide many educational researchers' conception of optimal learning environments (Glassman, 2001; Paul & Glassman, 2017). As a learning theory, constructivism derives from Piaget's (1952) cognitive learning theory of how a person processes and reasons information to learn, but separates learning from context. Vygotsky's (1962) socio-cultural view of constructivism holds that people construct, rather than acquire (Cunningham & Duffy, 1996), their own understanding of the world through experiences and their subsequent reflection on those experiences. This idea of *situated cognition* contextualises learning, allowing knowledge to act on and transform reality (Cunningham & Duffy, 1996).

Researchers working within this paradigm view knowledge construction as an exploratory process, where learners actively engage with their immediate ecology, individually as well as collectively, as they build more nuanced understandings of their worlds. As this research has these features then constructivism is the appropriate choice of methodology, as it is different from other cognitive paradigms such as an information processing approach which focuses on information encoding and retrieval strategies only at the level of the individual learner (Gardner & Hatch, 1989).

3.3.4 The use of constructivism as a methodology in higher education research

Researchers in higher education "are not always explicit about their methods and methodology … they just 'do' the research and then write it up" (Tight, 2013, p. 137). This pragmatic approach, of the practical rather than theoretical considerations, is perhaps the result of the usually few opportunities to do more detailed testing other than gathering learning experiences and learning outcomes in response to some intervention. Further, theory choice varies dependent "on the scope and purposes of the intervention [and] the funding available to resource the research" (Bell, 2020, p. 98). Compound these observations with the diverse discipline backgrounds of the researchers and "[i]t is probably more useful … to regard higher education as a field of study, researched from a number of disciplinary perspectives" (Tight, 2013, p. 138). The forum for higher education research from any field is generally higher education journals, with a more limited number of discipline specific education journals (e.g., *Accounting Education* and *Medical Education*). Although not always obvious, constructivism using mixed methods as the central methodology was found to be employed by the vast majority, 91% (Tight, 2013) of higher education researchers. Regardless of whether or not research on higher education is funnelled into a narrow range of methodologies favoured by particular journals, higher education is "an aspect of the social world. [I]t is most appropriate to research higher education using social research methods and methodologies" (Tight, 2013, p. 149). The central precept of constructivism holds that learning is a social enterprise, placing the learner at the centre of the research, and as such, is a good fit for this research.

Fosnot (1996) provides the following principles of the theory of constructivist learning:

- learning is development, not merely a result of development,
- liminal states precipitate learning,
- social communication fosters critical thought,
- reflective practice motivates further learning, and

- scaffolding develops and embeds schemas.

In summary, constructivism is "a psychological theory … that describes how structures and deeper conceptual understanding come about, rather than one that simply characterizes the structures and stages of thought or one that isolates behaviours learned through reinforcement" (Fosnot, 1996, p. 30).

Perkins (2006, p. 34) went on to recognise three distinct learner roles in constructivism:

- Active learner – where knowledge and understanding are actively acquired and learner driven,
- Social learner – where knowledge and understanding are socially constructed, and
- Creative learner – where knowledge and understanding are created and recreated.

Simon (2016) identified constructivism as ideally suited as the pedagogical theory in the wider interdisciplinary field of *e-learning*, including gamified learning. Constructivism in learning means that when learners encounter new information they link it to their existing knowledge and understanding, building on already established schema (Biggs, 2003). Constructivism in e-learning extends to empower students to challenge information presented by teachers, to reflect on their learning, and "develop their own understandings instead of accepting a pre-structured model" (Simon, 2016, p. 204).

The prevalence of constructivism as the chosen methodology for higher education research (e.g., Bell, 2020; Perkins, 2006; Simon, 2016; Tight, 2013) and the enduring principles and theories put forward by Fosnet (1996), guided the choice of research approach. Because this research investigates how students construct knowledge of threshold concepts in a gamified learning environment then constructivism is the appropriate choice of methodology.

3.3.5 Social constructivism

From the individual structuring of constructivism or cognitive constructivism, has grown a counter perspective of "emphasizing the sociocultural effects on learning" (Fosnot, 1996, p. 23). Social constructivism, derived from sociology and communication, holds that associated experiences of the world form the basis of understanding. These experiences are then rationalised and made real through the creation of social models, communicated and shared through language (Leeds-Hurwitz, 2009a). In fact, researchers:

> [S]eek understanding of the world in which they live and work [and] develop [multiple and varied] subjective meanings of their experiences … directed towards certain objects and things … leading the researcher to look for the complexity of views rather than narrowing meanings into a few categories or ideas. (Creswell, 2011, p. 8).

Here methodology guides choice of methods, where methods are the techniques and tools for collecting (surveys, interviews, experiments, etc.,) and analysing (thematic, content, narrative, discourse, grounded theory) data. The general researcher is directed to a qualitative approach with open-ended questions, addressing the process of interaction as well as context (Leeds-Hurwitz, 2009b).

Game-based learning pedagogy is grounded in the theoretical framework of social constructivism (Kapp, 2012, 2016; Kapp & Driscoll, 2009). While there are, and have been, many games that are not necessarily networked, being networked is not necessarily a precondition for social constructivism to exist. It is well established that interaction with other learners' avatars or artificially generated non-player characters is perceived by learners to be social (e.g., de Byl, 2013; Ding et al., 2017, Kapp, 2012). By inference then, it follows that this may even extend to interaction with learning materials that are representations of the teacher, but in the form of animated objects or artefacts. This is an important factor in considering the teacher presence as a guide in the learning journey, with the teacher's representative avatar used to communicate with the student to move them toward specific learning needs and recognise achievements.

With an emphasis on learning via collaboration, Vygotsky (1978) theorised that learning was not simply "the assimilation and accommodation of new knowledge by learners; it was the process by which learners were integrated into a knowledge community" (p. 57). He placed more emphasis on the social context of learning than acquisition of knowledge. Game based learning – in particular, role play – by definition and design engages learners in a social learning activity. Social constructivism addresses student motivation in terms of behaviour (extrinsic) and cognition (intrinsic), and posits that social behaviour reward and active internal construction of knowledge, combine to engage students in transformational learning (Bowen, 2005). Learning, in turn, becomes enculturation into a community of practice.

In social constructivism, social communication in any of its forms is recognised as being essential in a collaborative process of learning. This approach focuses on teacher-student interaction (Laurillard, 2002). There are two developmental levels: actual - where the learner is situated and already capable; and potential - the zone of proximal development (Vygotsky, 1978) – where learning takes place under the guidance of a teacher, in collaboration with peers, or both.

Learning as a social and collaborative activity, consistent with Vygotsky (1978), is not only shaped by the learners' experiences and sociocultural context, but also the teachers' interactions and experiences with the learners. The social aspects and benefits of play have been well documented in the literature, providing players with opportunities to explore social constructs, engage with other players, and develop communication skills (D'Angour, 2013; Fine, 2002; Parten, 1933; Vygotsky, 1978). The aim of gamification is to replicate those results in a learning environment. Learners will reach learning outcomes while they are collaboratively involved – individually or with non-player characters or peers in the GLE – and "learning is constructed through negotiation of meaning" (Simon, 2016, p. 204).

Social learning theory (Bandura, 1977) posits that behaviour is adjusted by direct experience in concert with reinforcement of observations and imitation. Kapp (2012, p. 70) articulates this as the effectiveness of "human social models … in influencing another person to change behaviors, beliefs, or attitudes, as well as social and cognitive functioning." Overlaying this on the GLE, learners "can be socially influenced by automated anthropomorphic agents (avatars), just as they would be by human social models" (Kapp, 2012, p. 70). The use of hypothetical scenarios grounded in real-world situations are interesting, relatable, and produce satisfying learning outcomes for learners.

A social constructivist research paradigm, employing an interpretive framework, facilitates an understanding of the factors which afford or constrain a gamified pedagogy in higher education (Riebe et al., 2016).

3.3.5.1 Implications for GLEs

In this research a constructivist methodology has been adopted. Specifically, the principles of social constructivism frame GLEs. This methodology reflects learning in GLEs as a social, collaborative activity. Learning occurs in a meaningful context, related to and building on learning and knowledge in the learners' real world (Andrew, 2012). In a GLE, a constructivist teacher creates the context for learning which engages learners in interesting activities that encourage and facilitate learning. Using hard and soft scaffolds (Kapp, 2012), the teacher assists learners as they approach problems, interjects with troublesome concepts to disrupt existing beliefs and advance critical thinking, interjects with *new* truths that challenge and question current understanding, and provides formative feedback.

3.3.6 The role of cognitive load theory in the theoretical framework

In the process of knowledge construction, capacity of learners is paramount. Cognitive load theory (see also Section 2.6.2) is also founded in the cognitivist theory of psychology where the primary focus is on increasing the learning efficiency of complex tasks, by examining working memory and long-term memory (Sweller, 1988). Paas and Van Merriënboer (1993) used a "calculational approach for combining measures of mental workload and task performance that allows one to obtain information on the relative efficiency of instructional conditions" (p 737). The *working memory*, where information is attended to, is limited to equal or less than, nine unrelated elements at once. This is Miller's (1956) Magic Number of 7+/-2: the number of elements that can be stored in human short-term memory. Information is then stored in long term memory in a hierarchical network of existing schema with unlimited capacity (Cooper, 1998). Figure 11 depicts Cooper's proposed modal model of memory, distinguishing between three memory types, or modes, and showing how these are "integrated to define an information processing model of human cognitive architecture" (Location 2.3).

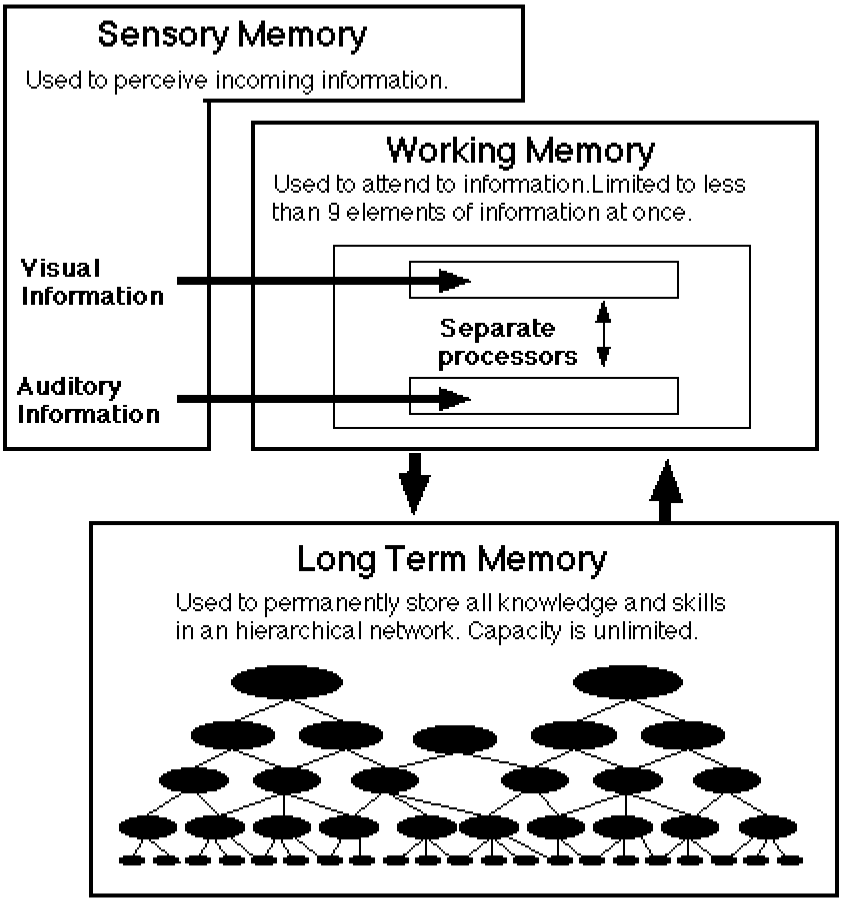


Figure 11 **Modal model of memory (Cooper, 1998)**

As discussed in Section 2.6.2, cognitive load in learners comprises of three distinct types (Sweller et al., 1998): (1) intrinsic load, the natural working ability and utilisation; (2) extraneous load, the unnecessary load placed on working memory because of the instructional method; and (3) germane load, the complexity of material and element interactivity that effects the learner's ability to comprehend and develop schema (Mostyn, 2012,). Constructivism is the method of constructing that schema (Sweller, 1988). Learners construct their knowledge on a foundation of understanding reality in the context of personal experience. It is incumbent on the learning designer to reduce non-necessary extraneous load and promote load that is germane (Chandler & Sweller, 1991).

The implications for game software as a learning resource in accounting education – creating awareness, interest, and achieving learning outcomes through applied teaching methods – are strengthened through research grounded in cognitive load theory.

> Gamification is an approach that can make …
> immersion easier, lessening the cognitive load of the
> students in [e-learning] environments and aiming for an
> enjoyable experience. (Simon, 2016, p. 208)

For example, the cognitive load theory research of Mason et al. (2016) demonstrated the effective use of activities to ensure a sense of achievement as early as possible in the learning process. It thus follows that an *early achievement* in a GLE will take the form of a reward or positive progress feedback to the learner in first few actions or decision-making stages achieved via procedural efficiency (Mostyn, 2012). The subsequent promotion of self-efficacy – the learner's belief in their ability and capacity to achieve their goals, and preparedness to undertake challenging tasks to meet those tasks rather than avoid them (Bandura, 1982) – provides the motivation to continue. Bloom (1956) refers to this as early success for a motivating positive effect on performance.

3.3.7 Generalised theoretical framework

Laurillard (2002) encapsulated the constructivist, social constructivist, and cognitive learning theories and presented a *conversational framework* against which to evaluate the effective use of learning technologies in higher education. Her framework "situates learning as a relationship between the learner and the world, mediated by the teacher" (Laurillard, 2002, p. 86). The conversational framework (Figure 12) identifies the activities – through any medium or combination of media - necessary for the completion of the learning process and represents this as a discursive (activities 1-4, across the top), adaptive (5 & 10, at both sides), interactive (6-9, across the bottom), and reflective process (11 & 12, also at both sides), central to academic dialogue.

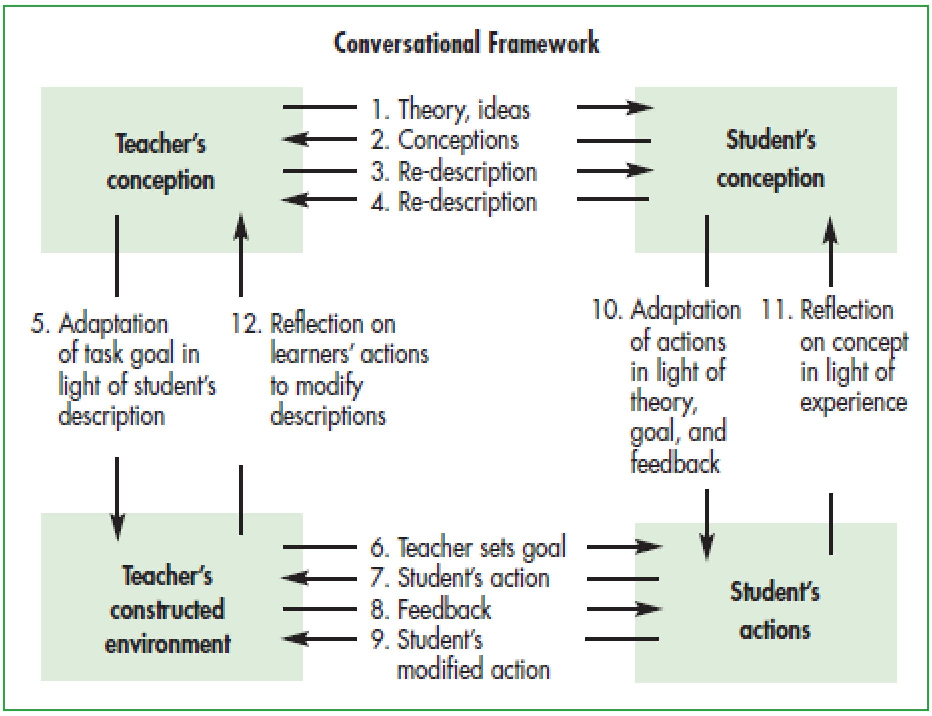


Figure 12 The conversational framework (Laurillard, 2002, p. 87)

Laurillard's conversational framework (2002) considers and explores both teacher and learner conceptions, teacher's constructed environment, and student's actions, and the activities that connect these domains. Using the conversational framework as a starting point, this research recognised that there may be fewer activities or variables in a GLE than a face to face learning experience, but the relationships or interfaces persist in the online environment. Following these relationships, the researcher created the **generalised conversational framework** (Figure 13), which now shows a core of *constructivist theory* (Cunningham & Duffy, 1996, Gardner, 1985, Vygotsky, 1962) given that learners' construct knowledge through exploration. This is enveloped by a synthesis of *social constructivism* (Fosnot,1996; Kapp, 2012; Leeds-Hurwitz, 2009b; Vygotsky, 1962), where learners reflect on their experiences of the world to form schema of knowledge, together with *cognitive load theory* (Cooper, 1998; Mostyn, 2012), where learning efficiency increases through management of cognitive load for comprehension and schema development. The researcher framed the core within the conversational framework of the teacher and learner around the learning, where the constructed learning environment is described, engaged with, reflected upon, adapted, and re-described in a continuous flow of perception and knowledge construction (Laurillard, 2002). Design and redesign of the learning experience then "bring[s] together [the] multiple perspectives and skills … of teachers, students and technologists, to codesign learning experiences", and all contributors therefore have "agency as designers" (Warburton et al., 2020).

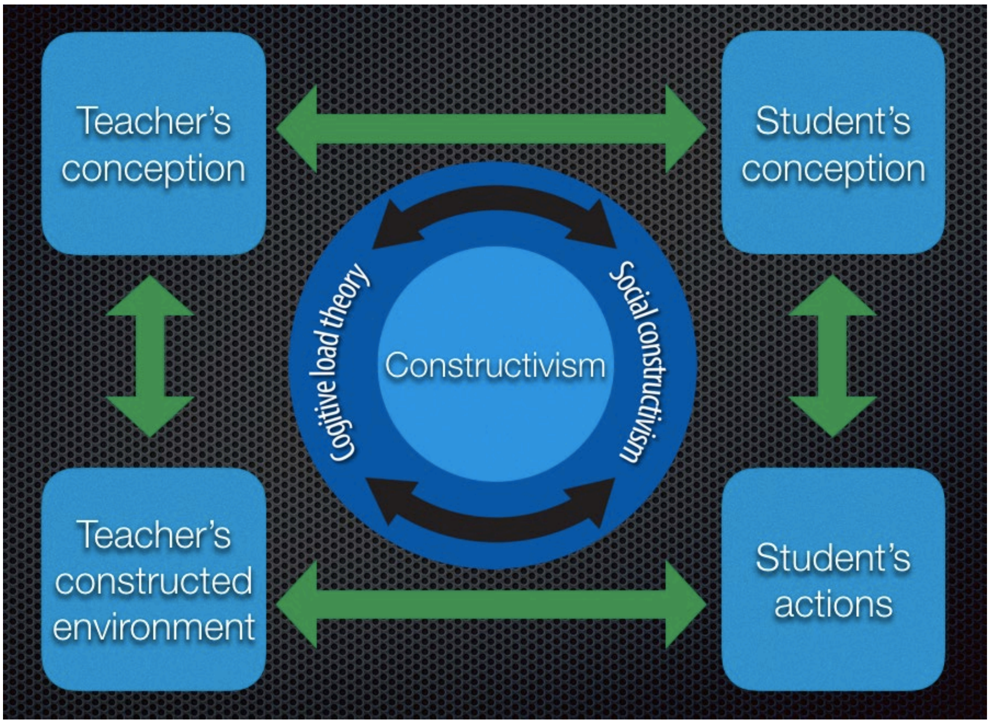


Figure 13 The generalised conversational framework developed for this research (Wood, 2019) (Adapted from Laurillard, 2002)

Navigating the **generalised conversational framework** in a clockwise direction, moves from the teacher's and to the student's conception across the top, where the GLE is conceived and designed by the content expert and implemented when delivered to the student. Down the right-hand side the student perceives the content and engages with the GLE demonstrated by their actions within the GLE. teacher's constructed environment, and student's actions, and the activities that connect these domains. Across the bottom of the framework, students' engagement and performance results with the content of the GLE are measured in the teacher's constructed learning environment. Up the left-hand side of the framework, the teacher reflects on the student's performance and experience with the GLE, leading to revision and redesign of the GLE for the next iteration. The double ended arrows signify the two-way flow of *conversation* between the four corner *domains*, facilitated and represented in a GLE in the form of scaffolds, feedback received, reflection, and change of actions for students, and reflection, adaption, and redesign of the GLE constructed environment for teachers.

Although there is heightened interest in the potential of, and "intrinsic educational value" (Marklund & Taylor, 2016, p. 122) of game-based learning, there remains little integration. Marklund and Taylor (2016) further found that "literature has emphasised the game artefact and player-game relationship for viability and efficacy of games as learning resources" (p. 122). From an epistemological perspective, there are claims of high potential and positive correlation between gaming and learning, but there is a lack of literature and measurement about the effectiveness of games as teaching tools in formal learning settings. Noesgaard and Orngreen (2015) advocate the use of methodology other than "only using the fulfilment of pre-defined learning objectives … to see unexpected and unintended changes in practice that occur as a result of the e-learning program" (p. 288). The **generalised conversational framework** now defines a space for exploring the interactions and relationships that occur between and within teacher and learner conceptions teacher's constructed environment and the critical reflection thereon (Brookfield, 2017), and student's actions.

3.4 Hypotheses

The three areas of the literature review – gamification of learning, learning design for student engagement, and threshold concepts – investigated the landscape of the research questions:

1. How can a gamified learning experience enhance student engagement in learning about technical threshold concepts of accounting and finance?
2. How can a gamified learning experience enhance student learning outcomes in technical threshold concepts of accounting and finance?
3. How can the enactment of the principles and framework of gamification in the delivery of technical threshold concepts in accounting and finance enhance student self-efficacy?

4. How can the enactment of the principles and framework of gamification contribute to the learning design for the teaching of technical threshold concepts in accounting and finance?

To examine these questions within the theoretical framework the following hypotheses were formulated to explore the interactions of learner-teacher, learner-content (Moore, 1989), learner-non-human resources (Hamari et al., 2015), and teacher-non-human resources in the GLE activity. The hypotheses are displayed in Figure 14.

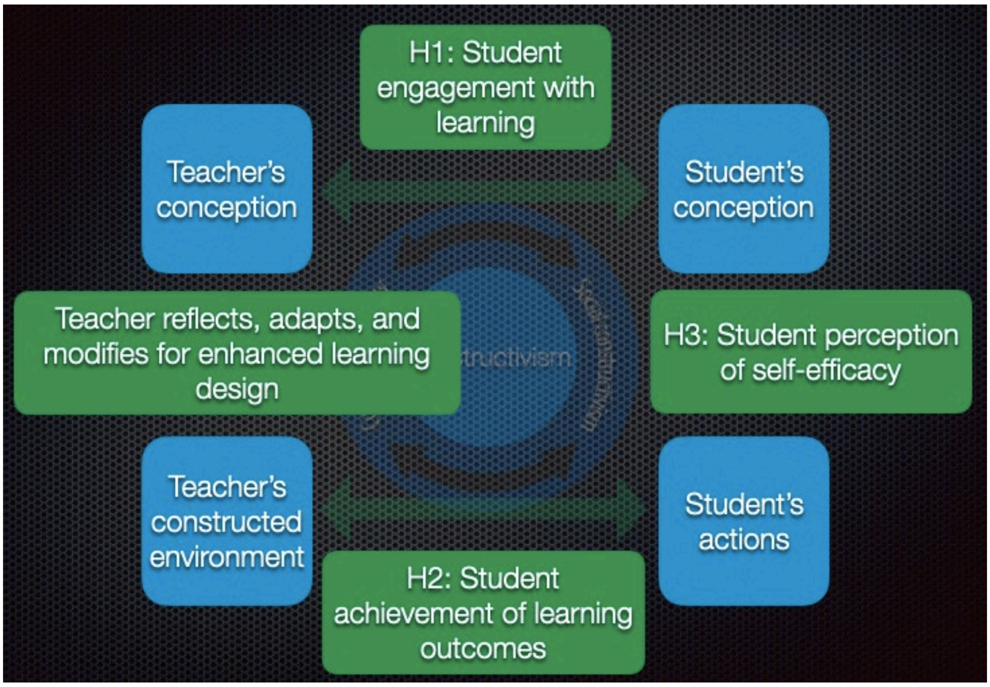


Figure 14 The hypotheses positioned within the generalised conversational framework developed for this research (Wood, 2019)

In Figure 14, hypothesis 1 is discursive between the teacher's conception and the student's conception, where theory and ideas are transposed by the teacher into the GLE. Hypotheses 2 is interactive between the teacher's constructed environment and the student's actions, where learning actions occur, students receive feedback within the GLE, and learning outcomes are measured. Hypothesis 3 is adaptive and reflective, between the student's conception and the student's actions, where students experience learning within the GLE and adapt and reflect on their understanding and the experience. From the proceeding hypotheses, the following design contribution was expected to be adaptive and reflective between the teacher's conception and the teacher's constructed environment. This is where teachers reflect on learners' needs and actions, and adapt an modify the GLE accordingly.

3.4.1 Hypothesised model for testing

The three hypotheses all directional hypotheses which predict a positive change or relationship between two variables. Figure 15 presents the flow chart of how the hypotheses work together from design of the GLE treatment affecting learner engagement, learner efficacy, and learning outcomes, which then loop back to enhance the original design.

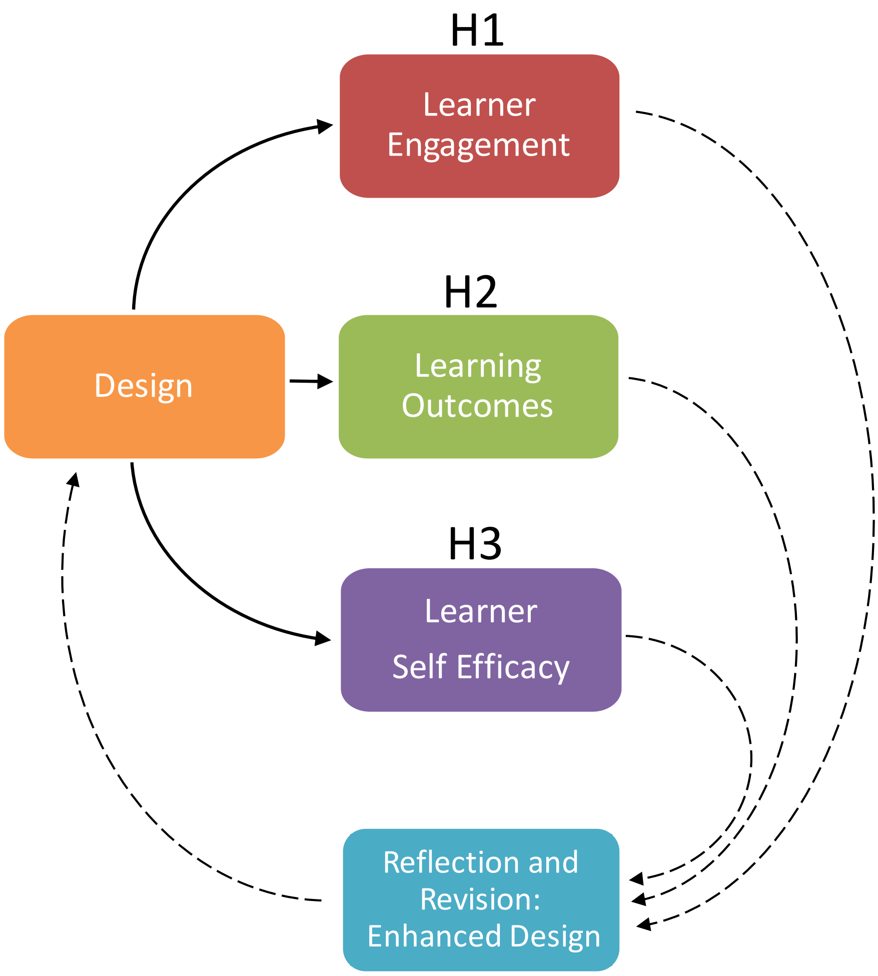


Figure 15 **Flow chart of hypotheses testing**

3.4.2 eGameFlow

The instrument used to test the hypotheses was eGameFlow (Fu et al., 2009). In developing eGameFlow, Fu et al. (2009) administered their 56-item survey to 166 online students in an introduction to software course. The students completed the survey based on their experience in one of four different styles of e-learning games, each requiring a different type of knowledge acquisition: (1) a motherboard-assembly pairing game for identification, (2) a game of describing computer parts for understanding of attributes, (3) a practical operating system game for problem solving, and (4) a simulation game for evaluation. Using the descriptive statistics of mean and standard deviation for item analysis, most items were adequate with small standard deviation and high discriminative power. However, in their analysis, Fu et al. (2009) found their items measuring social interaction displayed a greater variation, putting this down to the lack of social interaction as a mechanism in any of the four games. As previously stated, for this reason, this factor was omitted from the survey for this research. In their factor analysis of the original 56 items, correlation was present in 2, and 5 failed to load testing at < 0.3. Fu et al.'s final survey contained 55 items. Using KMO (0.87) and Bartlett's test for sphericity (8235.0, $p < .01$) the data was found to be satisfactory. using principal-axis factoring with extraction at an eigenvalue of > 1, and factor loadings using varimax orthogonal rotation of > .4:

> [S]ome items did not load with the expected factor dimension or loaded simultaneously in two dimensions, [which was] resolved by omitting some of the problematic items and re-categorizing the dimensions identified [Ultimately extracted 8 factors with 42 items. The] Cronbach's alpha was 0.942 for the 42 items as a group and > 0.8 for each separate dimension, showing that the scale developed for [the] study had high internal consistency and reliability. (Fu et al., 2009, pp. 110-111)

eGameFlow has since been validated by Shu-Hui et al. (2018), to further the "development of a relevant model for measuring user enjoyment of video game play" (p. 6:1). However, because their intended usage was for game developers and engineers, they retained the social interaction dimension and omitted the knowledge improvement dimension as not relevant to their research. Using confirmatory factor analysis with a factor loading benchmark of > .4, Shu-Hui et al. (2018) found their model was improved by the deletion of four items from Fu et al.'s (2009) original list. Two of these were not included in Fu et al.'s (2009) final eGameFlow survey and therefore not considered for this research. One item was from Social Interaction, a dimension not included in the eGameFlow survey administered to participants as explained above. The fourth item was from Concentration: "The workload of the game is adequate" and given the learning purpose of this research, it was not prudent to remove this item. Although correlations between the factors were high, Shu-Hui et al. (2018) found the factors to demonstrate discriminant validity and concluded that eGameFlow was reliable and valid, and pointed to the "impacts that demographic factors have on players' perceptions of game-playing experiences" (p. 6:11) for further investigation.

Silva et al. (2019) have also used eGameFlow in their research to "measure the influence of the various dimensions … on the creation of a flow effect on students in a gamified learning context" (p. 490) in accounting and marketing education. Using confirmatory factor analysis with a factor loading benchmark of > .5, Silva et al. (2019) found their model was improved by the deletion of six items from Fu et al.'s (2009) original list: two items from each of Learning, Concentration, and Autonomy. The two items from the Learning factor were not included in Fu et al.'s (2009) final eGameFlow survey and therefore not considered for this research. Removal of the items presented only a modest improvement (CFI 0.905 increased to 0.974) and given the learning purpose of this research, as opposed to the flow effect being investigated by Silva et al. (2019), these items: "I was not distracted from the learning task", "I was not burdened by tasks that seemed unrelated", "I felt a sense of control and impact over the game", and "I understood the stages of the game" were retained.

3.4.2.1 eGameFlow factors

After familiarisation with, and examination of, the data collected via the survey instruments, multivariate ANOVA was conducted for each hypothesis. eGameFlow as a set of factors collectively measures usability, and enjoyment rendered as a result of increase in skill and knowledge improvement. The eight factors were grouped to accurately describe the hypotheses being tested, with some factors explaining more than one hypothesis. Table 6 below illustrates which instruments, and the factors within the instruments, were used to test each hypothesis.

Table 6 **Measurement instruments employed for each hypothesis**

Measurement Instruments	Measure	H1: Engagement	H2: Performance	H3: Self efficacy
Learning outcomes test				
Qs 1 – 14	Correct/incorrect		X	
Pre test/post test	Correct/incorrect		X	
Post test v historical data	Correct/incorrect		X	
eGameFlow survey				
Factors:				
Concentration	5-point Likert scale: 0-4	X		X
Goal clarity	5-point Likert scale: 0-4		X	X
Feedback	5-point Likert scale: 0-4		X	X
Challenge	5-point Likert scale: 0-4	X	X	X
Autonomy	5-point Likert scale: 0-4	X		X
Immersion	5-point Likert scale: 0-4	X		
Knowledge improvement	5-point Likert scale: 0-4		X	X

Research Ethics was sought through Southern Cross University and granted in ECN-17 229 on 9 November 2017.

3.5 Summary

This chapter has mapped the language and terminology of pedagogy and gamification to present a **gamification alignment table** and a descriptive **gamification alignment model**. The constructivist methodology was identified as the appropriate methodology for this research. The theoretical framework for this research has been generalised with constructivism at the core, and encompassed by social constructivism and cognitive learning theory, all within Laurillard's (2002) conversational framework. This **generalised conversational framework** is then able to be used for exploring the interactions and relationships that take place in the gamified learning experience (GLE), and how these contribute to learner engagement in, motivation for, and performance of learning. The following chapter provides an overview of the choice of research methods and instruments employed for data collection, measurement of key variables, and data analysis. It then describes the implementation of the GLE experiment, and the collection, validation of data, and the sample description.

Chapter 4 – Method

4.1 Introduction

The previous chapter developed a **gamification alignment table** and a descriptive **gamification alignment model** to guide the development and evaluation of gamified learning experiences (GLEs) in delivering technical threshold concepts in accounting and finance education. The theoretical framework – the **generalised conversational framework -** for this research was modelled, with constructivism at the core, and encompassed by social constructivism and cognitive load theory, all within Laurillard's (2002) conversational framework. This chapter provides an overview of the choice of research methods and instruments employed for data collection, measurement of key variables, and data analysis. It then describes the implementation of the GLE experiment, and the collection, validation of data, and the sample description.

4.2 The time value of money gamified learning experience

To answer the research questions a **time value of money gamified learning experience game** was created for this research. Appendix 1 details the researcher's actual development of, and reflection on the experience of developing, the experiment treatment, the time value of money gamified learning experience.

The development of the GLE went through the various design phases, starting with identifying the type of game, as a narrative role play, to develop the learner player's knowledge for making optimal financial decisions. The game world created was a university campus with character choice and contextualised scenarios that would be familiar to students. Episodic play was aligned with the learning outcomes for the threshold concept of TVM, using the standard definitions, formulas, and notations for future value and present value. The design map contained 3 levels of play mapped to 3 scaffolded phases to build learning. The narrative of the GLE was informed by and aligned with the literature on accounting pedagogy, cognitive load theory, and authentic learning. Consideration was given to engagement of learner players via personalisation and rewarding game experiences, which also motivated and propelled them through the levels of the GLE. The design allowed for choice in learning pathways through the GLE, with formative feedback points, in the form of clues and scaffolds with definitions, formulas, and examples, as well as options for repeats to self-pace and build learning.

Much consideration was given to software options for the delivery platform, with the final decision also being informed by cost, time, and the researcher's technological capacity. The choice of iSpring to deliver the GLE provided a digital atlas of pre-coded content and a development platform that launched from the university learning management system. The iSpring platform worked with PowerPoint and allowed for an episodic non-linear story line. Backgrounds, avatars (character representations), icons, and artefacts were all curated and matched to the TVM threshold concept utilising the Gamification Alignment Table (Section 3.2.2).

A parallel control group learning experience was created and matched exactly to the GLE using traditional linear pedagogy delivered through a PowerPoint video. Both versions were beta tested before release for data collection. Some minor edits were made relating to signposting progress and clean navigation, as well as the decision to include a pre and post learning outcomes question. The take outs from the design process were: (1) seek and take advice from experts, (2) beta testing is essential, (3) take note of how others interact with the GLE, and (4) evaluate of these forms of feedback and make iterative changes and improvements.

The finished game was a fully self-contained product that included the collection of demographic and survey data, and the learning outcomes assessment. Appendix 2 contains a standalone link to the Time Value of Money learning game.

4.3 Research methods and conditions for selection

The generalised conversational framework used in this research is characterised by an interconnection of the participants' philosophical worldviews (social constructivism), which informed the selected strategies of inquiry (mixed methods sequential strategy), and research methods employed (learning experience, survey, follow up interviews, data collection, data analysis, interpretation, write-up, validation). The experimental research practice of collecting qualitative data on an instrument or test and gathering information on a behavioural checklist (Felder & Silverman, 1988), was followed by the application of a quantitative survey instrument using both closed and open-ended questions. This allowed for both statistical and text analysis, and supported a constructivist philosophical assumption of participatory knowledge claims (Creswell, 2011, Gray, 2014). This mixing and integrating data at different stages of inquiry presented a holistic picture of the procedures in the study (Gray, 2014) and the findings produced.

When experimental research is selected, research participants are randomly assigned to either a control or an experiment group, and the results of the application of the experiment compared (Creswell, 2011; Gray, 2014). Congruent to that process, this research measured student experiences and outcomes (dependent variable) after the application of the GLE experiment (independent variable), to test the "initial hypotheses through empirical qualitative observations and quantitative experimentation" (Gray, 2014, p. 37). Thematic inductive analysis of the qualitative data gathered within the constructivist epistemology from follow up interviews (Braun & Clarke, 2006), and deductive quantitative measurement of outcomes was then extrapolated from the sample to greater populations and used to refine a framework of gamification alignment for the design of future GLEs.

As discussed in the previous chapter, this research took on a constructivist epistemology, with an interpretivist theoretical perspective. The research approach was mixed, using observations and environmental context to induce the hypotheses, with deductive reasoning to determine the experiment design, for a cross sectional study of students in the broader business disciplines which include the TVM technical threshold concept predominantly in first year accounting and finance units. Surveys were used to capture experience and attitudes, and the GLE measured performance.

4.3.1 Mixed methods

The triangulation of qualitative and quantitative sources of data has developed into a distinct methodology (Creswell, 2011), where an array of data collection practices "reinforc[e] rather than compet[e] with one another, thus striking a balance between qualitative and quantitative methods" (Gray, 2014, p. 199). Mixed methods research design first seeks to explain the relationships between variables (quantitative), then explores how this is played out (qualitative). Surveys and multi-variate analysis are predominant in higher education research (Tight, 2013). Statistical analysis and reporting from Likert scaled surveys ranges from frequency and mean exposition, through *t* tests and analysis of variance, to correlation and regression testing, and in larger samples, structural equation modelling. In conjunction with these quantitative methods, participant responses to open-ended questions in follow up interviews are used to distil themes for qualitative analysis to better understand, explain, and build on the results of the quantitative analysis.

The application of sequential, mixed-methods "begins with an exploratory, qualitative framework which helps toward the identification and classification of themes and concepts" (Gray, 2014, pp. 199-200). The results from a quantitative survey are then:

> [U]sed to identify important themes that [the next stage of] qualitative [research can be used to] deepen … and identify contrasting groups of respondents … for follow-up qualitative interviews to gain an in depth understanding of differences. (p. 202)

Mixed methods design is therefore, the combining of quantitative and qualitative research methods to explore sequentially the quantitative relationship between variables, and the intricacies of why and where variables intersect. The qualitative is used to explain and increase understanding and build on the results of the quantitative. In the field of higher education, especially learning design, the use of mixed methods provides a forum for participants' voices and informs the next iteration of the research, using quantitative (surveys) and qualitative (focus groups) data (Kavanagh & Drennan, 2007).

This research used sequential mixed methods utilising the instruments of: a self-report digital learner characteristics questionnaire, assessment of learning test, survey with Likert scale responses, online discussion board, and follow up interviews. The empirical data obtained was measured and triangulated in three ways:

1. Engagement with learning: eGameFlow survey, follow up interviews, and discussion board. (H1)
2. Performance: assessment within the GLE, eGameFlow survey, follow up interviews, and discussion board. (H2)
3. Self-efficacy: confidence in knowledge gained and its future application via eGameFlow survey, follow up interviews, and discussion board. (H3)

The phases of the research design and methods used are depicted in Figure 16.

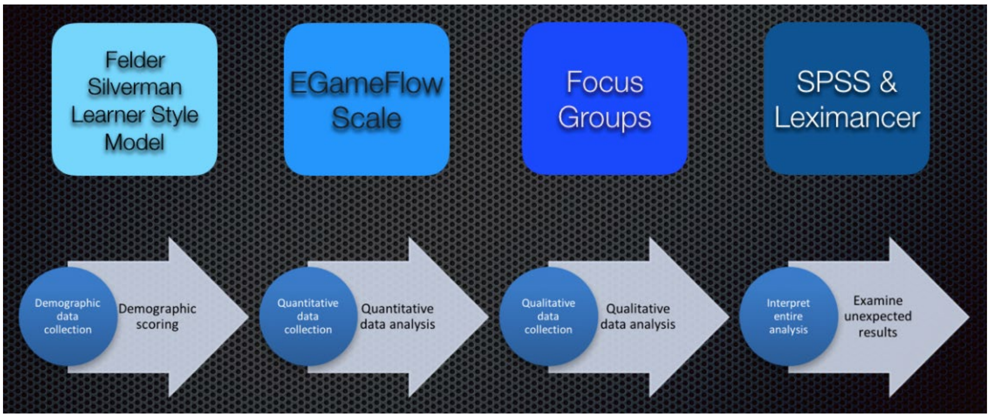


Figure 16 Phases of sequential mixed-methods design, showing methods used at each stage

The reason for including both quantitative and qualitative methods was to examine and inform the design of the framework for design and evaluation of GLE. The research began by revealing learners' preferences through the Felder-Silverman learner style index questionnaire. In the next stage, performance outcomes for each participant were investigated by examining the results obtained in the GLE. Concurrent with this, quantitative statistical results from the sample eGameFlow surveys were obtained. Subsequent to these, follow-up interviews were held with a few participants to help to explain and explore the results in more depth. This connected means of mixing quantitative and qualitative means between the phases of data collection (Figure 16) relies on the synthesis and timing of the different aspects. It provides a secondary form of data in a different form, in a supporting role (Creswell, 2011).

4.3.1.1 Variables

The independent variable in this research was the application of the GLE to the experimental group (not applied to the control group). The effect on, and measurement of, learning outcome and experience of the learning experience were the dependent variables (Gray, 2014). The variables of this study were investigated within the generalised conversational framework using the generated hypotheses. While games have been studied for their existing qualities as situated artefacts or activity (Eklund, 2012), this research examined the gamification structure (scaffolds) and inclusion of components (the story or plot driven narrative) surrounding the artefact (GLE) to measure engagement, motivation, and self-efficacy of learning, in addition to learning outcomes.

4.3.1.2 Control and treatment groups

Participants were randomly assigned to either the control group (who received a traditional teacher to learner video TVM instruction) or the treatment group (who received the TVM GLE treatment). The terms *control* and *treatment* were used to match the terminology used in SPSS, the data analysis package used. In the first section of the experiment, participants provided key demographic data to be used as control variables in the analysis.

4.3.1.3 Index of Learning Styles

Both groups then completed a 44 a-b question qualitative self-report survey, the Felder and Silverman learning styles index (Appendix 3), which has been highly regarded, and extensively used in, educational research and e-learning (e.g., Dominguez et al., 2013; Graf et al., 2007, Hamari et al., 2015). Dominguez et al., (2013) described their use of the Felder and Silverman learning styles index in an e-learning experimental design research setting involving physics students, as allowing for not only measurement of achievements and attitudes of participants in the experiment, but also informing the analysis of the results within the experiment.

Recall the elements of the Felder-Silverman model (Section 2.4.3.2, Table 2) parallel the multiple ways content is presented to learners in a GLE: sensing and intuitive by allowing multiple attempts; visual by using video; verbal using sound and discourse; active by allowing the learner to be the driver of the learning activity; reflective by encouraging evaluation of action and repeat attempts; sequential through the use of constructive learning building on schema; and global by contextualising theory and concept, through the use of a plot-driven narrative.

The application of the Felder and Silverman learning styles index in this research assisted in determining a base line of learner characteristics for each group before interaction with the experiment. The questionnaire was scored by the researcher in line with the scoring key available to faculty at educational institutes for educational purposes. The analysis of survey results demonstrated the lack of any statistical difference between the two groups of participants. The results further served as markers for discussion, comparison, and analysis of actions taken and results achieved by participants within the GLE.

4.3.1.4 Progression through the gamified learning experience

Rather than a passive observer to the unfolding of a scenario, the learner in the GLE is placed at the centre of the story and has the capacity to make choices and determine the progress and path of the GLE. The learner inhabits the central character and has active control over the direction of the GLE, changing or tailoring the gameplay to match their understanding and choices as they progress through the learning experience. In order to achieve this, a background story is created to give history and context to the GLE (Bopp, 2007). The use of plot driven narrative in a GLE brings the discrete concepts and the greater environment view together. "Narrative requires relationships … and intermingling of beliefs, images, meanings. … With narrative [learners] populate [their] rationalities" (McNamee, 2004). The plot driven narrative moves the learner through the story of the GLE supplying artefacts, information, hints, and expanded story lines. The learner assimilates the concept, applies it, then analyses and evaluates the outcome, with continuous and immediate feedback after each decision.

The TVM GLE used episodes as iterative learning stages. In the initial encounter with the GLE, the learner was presented with a future value dilemma where they applied the background story and used the game resources to decide between two investments. Once the decision was made, they were asked to reflect on why that was their choice. They were then given the opportunity to return to the beginning of the GLE and take the alternate choice, then reflect on the outcome and the comparison of the two. Multiple repeats of both choices were available at the learner's discretion.

Once the learner had completed the future value episode to their own satisfaction, they moved to a second episode where the story continued and was expanded to include the concept of present value. In this episode the learner was provided with additional information and resources to decide between holding or selling an investment. Once the decision was made, they were again invited to reflect on their choice. They were given the opportunity to return to the beginning of this episode and take the alternate choice, again reflecting on the outcome and comparison of the two. Multiple repeats of both choices were available to the learner. The GLE treatment development is fully described in Appendix 1:Experiment Design.

4.3.1.5 Assessment of learning

Recall that the two accepted methods of teaching TVM are: via the textbook method using tabulated factors, and activity-based student-generated mathematical solutions (Dempsey, 2003). This research used the ubiquitous exercises found at the end of the textbook TVM chapters to build the questions to be tested within the GLE, that is, the threshold technical concept understanding, application, analysis, and evaluation. Examples of questions and problems are usually framed in a generic form:

> Future value: You receive a graduation present of $2000 and you plan to invest it in a fund that earns 6% each year. How much will you have in 3 years?
>
> Present value: You are saving to buy a house and need a deposit of $8900 in 5 years' time. If you can invest in a fund that pays 7% per annum, how much will you need to invest today?

From the discussion on real-time decision making, it is evident that these methods only address understanding and application of the accounting and finance technical threshold concepts. The GLE expanded the questions into choices, reflection and analysis of how these choices were made, and evaluation of the outcomes of different choices. The final level, Level 4, of the GLE was the Learning Outcomes Assessment (Appendix 4). This was an online quiz with a mixture of multiple choice and calculation questions, testing both theory and application.

4.3.1.6 eGameFlow survey

The next phase of data collection was quantitative with the application of a survey. This phase built on the first qualitative questionnaire data phase to measure participants' expectations, experience, and perceived learning within the GLE.

The evaluation tool used for this research was developed and refined by Fu et al. (2009), as a self-report scale for measuring user experience in e-learning games. They had found that existing evaluation tools were aimed at establishing the usability of commercial games which were designed for leisure purposes, not for measuring any increase of knowledge or skills in e-learning games. They acknowledged that enjoyment and challenge were necessary elements for stimulating engagement and motivation and therefore useful dimensions to measure effectiveness of e-learning. Fu et al. (2009) drew on Csikszentmihalyi's (1990, 1996, 2008) flow theory, where an essential criterion for determining game effectiveness is player enjoyment (flow). Building on Sweetser and Wyeth's (2005) Gameflow: "an evaluation checklist for every factor [of flow], mainly for the purpose of assessing a player's level of game enjoyment and thus facilitating improvements in a game's application and design" (Fu et al., 2009, p. 104), Fu et al. (2009) recognised the purpose of e-learning games being not to entertain, but impart knowledge. They added a measure for knowledge improvement (Bloom, 1984; Chu et al., 2006) to develop the EGameFlow Likert scale survey (see Appendix 5) to evaluate learners' experiences of e-learning games.

Fu et al. (2009) administered EGameFlow to 166 participants, using 4 different e-learning games, and found it demonstrated both scale validity and reliability. EGameFlow measures eight factors: concentration, goal clarity, feedback, challenge, autonomy, immersion, social interaction, and knowledge improvement. These factors corresponded sufficiently with the constructs being measured in this study. In order to use EGameFlow as a data collection instrument, and for measurement of the control group's expectations and experiences of the GLE, the items were reframed substituting "game" for "video" for the control group. The social interaction factor was removed from the final survey since the GLE for this research was a single learner application. The remaining seven factors were retained leaving a total of 30 items. The surveys were de-identified and the data analysed using the SPSS Statistics software package.

4.3.1.7 Follow up interviews

Adhering to Salmon's (2004) model of e-moderating (see Section 2.5.3, Formative assessment) supports for the learners' knowledge construction and development with e-moderating and technical support to be employed by the teacher were built in to the GLE. These were provided ancillary to the actual GLE, in the form of discussion board, additional assistance, and remedial trouble-shooting, as well as follow up interviews.

Participants were asked to indicate at the end of the experiment if they would be willing to participate in further discussion of the GLE and their experience, in the form of a follow up interviews.

> [Follow up interviews] allow researchers to explore the feelings, attitudes, beliefs, prejudices, reactions, and experiences of a subject, in a way that would not be so accessible through other approaches such as … survey. Sometimes these views might be held individually and be independent of a social setting, but often they will emerge from social interactions with other individuals and groups. (Gray, 2014, p. 470)

The emergence of qualifying data from a social constructivist setting aligned with the theoretical conversational framework of this research to strengthen the findings of the research.

Participants were asked to indicate their willingness to be part of follow up interviews at the end of the experiment. Using purposive sampling (Denzin & Lincoln, 2011), four participants were chosen to represent the characteristics of the sample: JP – female, domestic, undergraduate, EL – male, domestic, undergraduate; NH – male, international, undergraduate; and AS – male, international, undergraduate). This method of sampling of interviewees identified and selected participants from the total sample who had taken the opportunity to complete both versions of the experiment (Plano Clark &

Creswell, 2008), and were therefore able to comment on and compare their learning experiences.

4.3.1.8 Discussion board

A concurrent platform for participant comment and interaction with other participants was maintained on MySCU, the university's learning management site. The page was available throughout the duration of this research, and comments and suggestions recorded therein, used to inform the discussion stage of the research. The researcher moderated content where specifically requested to do so by participants. Participants were advised of the potential use of posted comments, and any comments made on the page were de-identified for use in the analysis and discussion of the research.

4.4 Data collection and sample

4.4.1 Administration of the experiment

Sampling variability refers to how well a sample accurately represents the population it is drawn from (Krippendorff, 2013). In order to recruit a representative sample of participants for the research, the lists of students enrolled in degrees, at the researcher's institution, where TVM was taught were obtained. These included all students in Bachelor of Business, Bachelor of Accounting, Bachelor of Digital Business, and Bachelor of Business Laws. In Session 2 2018, the population of these students numbered approximately 2950. From 8 August 2018, these students were emailed an invitation to participate in the research (Figure 17), outlining the requirements, time commitment, incentive, and learning experience, as well as researcher and ethics information.

An invitation to participate Kayleen Wood's PhD research study: A **GAMIFIED LEARNING EXPERIENCE** for Accounting Threshold Concepts

Reply to this email to get involved.

- The study involves your self-enrolment on the SCU Gamified Learning Experience BlackBoard site (I'll send you the link and instructions). You will be allocated to Group 1 or Group 2.
- Then you complete some information about yourself, and a digital learner's characteristics survey.
- Next you will work through the Time Value of Money experiment and answer some questions about what you've learned.
- Lastly you will complete a survey about your experience of the experiment.

This will take approximately 45 minutes to an hour to complete, but you will be rewarded with the chance to go into the draw for an iPad.

Plus you will have had an interesting experience and contributed to the future of learning and teaching.

Please REPLY to Kayleen Wood and she'll send you details of how to get started.

Researcher: Kayleen Wood, SBaT

Supervisors: Dr Jennifer Harrison and Dr Jacqueline Christensen

Southern Cross University Research Project Number: ECN-17-229

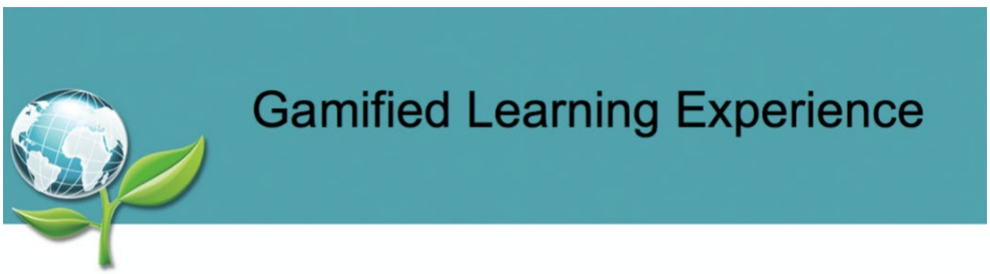


Figure 17 **Recruitment email to students**

This recruitment was supplemented with digital advertising across all three campuses of the university. The digital recruitment advertisement shown in Figure 18 was loaded and shown from August 2018 to June 2019.

Figure 18 **Digital recruitment advertisement**

In addition to these passive forms of recruitment, the researcher actively invited students to participate during Sessions 2 and 3 2018 Orientation Week activities and information sessions. The researcher personally attended tutorials for Financial Accounting, Taxation, Audit, Management Accounting, finance, and economics units to enlist participants, in Sessions 2 and 3 2018, and Session 1 2019. Direct follow up was made via blackboard emails to previous unit student cohorts for Financial Accounting and Taxation units. Tutors and unit assessors for the aforementioned units included the research announcement on the Blackboard sites for their units.

4.4.2 Response rate

By the end of Session 1 2019, a total of 91 students had expressed interest in the research: 45 had been allocated to the control group and 46 to the treatment group. An investigation of the breakdown of the sample in terms of the timing of responses, revealed no large groupings of participant responses other than slight up takes at the beginnings of sessions, and when the researcher made personal appeals to invite participants. The responses in the first 2 weeks of each session were: Session 2 2018, n = 13; Session 3 2018, n = 9; and Session 1 2019, n = 13. At the end of the data collection period a push for additional participants netted a further n = 15. The interim weeks contained the remaining expressions interests, averaging 2 per week. Of the 91 respondents, 74 (81.32%) enrolled on the Blackboard Gamified Learning Experience site and 68 (74.73%) completed the all parts of the experiment (28 in the control group and 40 in the experiment group). This equated to a response rate of 3.08% and a completion rate of 2.31% of the total estimated student population targeted. Although a small percentage of the population was represented, this is not necessarily an issue in this sort of experiment, as “treatments deployed in [opt-in online] cause similar responses for many subject types” (Coppock, 2018, p. 1). Further, the sample was drawn from the population of students with TMV as part of their degree, and greater than 50% of these students then used the GLE. For “generalisability of the survey experimental findings from this convenience sample to probability samples [of the population, examination of] the composition of the subject pools” (Coppock, 2018, p. 11) was required.

4.4.3 Non-response and response bias

The low response rate may have been attributable to the time requirement for participation in the experiment, especially if students perceived this as an extra task, even though the researcher went to great lengths to communicate the value of this learning as supplementing their current study. In this research, the identity of non-enrollers and non-completers was known to the researcher and these could be contacted by email. Follow-up emails did net some additional completions from the first round of recruitment activities. Further students who enrolled and had not completed all parts of the experiment were contacted directly by the researcher and prompted to complete. Those who eventually completed are all included in the final sample of 68 participants. Of those contacted and who gave reasons for non-completion, time was cited as the major factor. The students who both responded and completed may therefore be assumed to have been already engaged with their learning and motivated to take on additional learning tasks.

4.4.4 Coding and data entry

Data from the 68 participants who completed all parts of the experiment was deidentified and collated into Excel then entered into an SPSS Version 25 data file for review and coding. The demographic control variables requiring a choice from drop down menus were coded using single digits starting at 0. Index of Learning Style responses were scored on manual scoring sheet provided by NC State University, Richard Felder's Legacy Website https://www.engr.ncsu.edu/ils/, and then tabulated in Excel to provide a score for each dimension of integers from 0 to 11 for statistical analysis. Learning assessment data was checked for any discrepancies in symbols or syntax and adjusted if necessary. For example, although the online learning test was constructed to allow for a range of answers when a value or a calculation was required, in a number of instances participants answered .06 instead of 6 for the value of *i* as a percentage. Clearly, the answer was correct and was subsequently marked as correct. Multiple-choice question answers were coded using single digits starting at 0. eGameFlow survey responses were coded on a scale of 0 to 4. The addition of extra scale variables for eGameFlow and computations was performed in SPSS to retain the integrity of the data and avoid any manual errors. No cases needed to be deleted on the basis of missing variables.

4.5 Sample description

At the university where this study took place there are three study periods per year. These are called *sessions*. Session 1 is from March to June, Session 2 is July to October, and Session 3 is November to February. This study took place in 2018 and 2019. Data was collected from the GLE experiment from August 2018 to June 2019 to maximise the exposure of advertising to potential participant students over 3 consecutive sessions: Sessions 2 and 3 2018, and Session 1 2019. Participants were sought via digital advertising on campus, direct email to any students taking units housed in School of Business and Tourism, announcements on unit sites for finance, accounting, and taxation units, and personal requests made by the researcher in the first weeks of these units in class. Potential participants contacted the researcher via email and were alternately allocated to either Group 1 Experiment or Group 2 Control, to ensure random allocation. Participants were provided with a link to the research learning management system site, where they self-enrolled and then completed either the Group 1 or Group 2 activity as allocated. The links for both groups contained the same data collection instruments. Only the learning experience differed: GLE or video. All data was collated within the learning management system and extracted via SCORM reporting function. As each participant completed a survey instrument, the researcher was also notified via automatic email, which also contained completed survey information. Not all students who indicated they were willing to participate in the research activated their enrolment and some did not finish all the activities and surveys. At the end of the data collection period there were 68 full sets of data. Data screening, which is fully described in Section 4.7: Hypothesis testing procedure, identified one data set as a *multivariate outlier* and therefore excluded from the sample to be analysed. As a consequence, the **final usable data set sample count was *n* = 67: 40 *treatment* group and 27 *control* group**. As previously noted, the terms treatment and control were adopted for the GLE and video groups respectively for consistency with SPSS data analysis labelling.

The first section of the experiment collected participant demographics, which were used as control variables in the data analysis. Participants ranged in age from 18 to 68 years, with a mean age of 32.79 years and a median age of 30 years. The remaining control variables are summarised in Table 7: gender (male, female), study mode (on campus, online), student type (domestic, international), study level (associate degree, bachelors, honors, masters, doctoral), major (business, accounting, finance, administration/management, law, other), and whether the participant had studied time value of money (TVM) before (yes, no). The control variables of study mode, study type, and study level were included as these were regarded as likely to influence the way in which participants interacted with and understood the content. The control variable of major was included as it is "intuitive that students enrolled in degrees majoring in quantitative disciplines [of business, accounting, and finance will have a different perception and experience of an accounting and finance technical threshold concept] than those enrolled in the qualitative disciplines [administration/management and law]" (Christensen et al., 2018).

Table 7 **Descriptive statistics for control variables of sample (*n* = 67)**

		Number (Percent)
Gender[a]	Male	30 (44.8%)
	Female	37 (55.2%)
Study mode	On campus	50 (74.6%)
	Online	17 (25.4%)
Student type	Domestic	33 (49.3%)
	International	34 (50.7%)
Study level	Associate degree	2 (3%)
	Bachelors	32 (47.8%)
	Honors	22 (32.8%)
	Masters	10 (14.9%)
	Doctoral	1 (1.5%)
Major	Business	19 (28.4%)
	Accounting	34 (50.7%)
	Finance	1 (1.5%)
	Admin/Management	3 (4.5%)
	Law	4 (6%)
	Other	6 (9%)
Studied TVM before	Yes	37 (55.2%)
	No	30 (44.8%)

Note. [a] No participants identified as Other.

4.6 Measurement of key variables

4.6.1 Control variables – demographic data

Control is central to experimental research. To maintain this control and therefore the ability to compare effects of a treatment, the characteristic of each group should be the same. Demographic data obtained from participants who were randomly assigned to either the control or the treatment group was examined to ensure these characteristics were not significantly different. Included in the demographic data was a question requiring participant to indicate if they had studied TVM before and if so their level of confidence: amateur, proficient, or expert. There was then a question to pre-test their ability. This question was drawn from a test back of previous exam questions, of which historical data was available for comparison.

4.6.2 Independent variables

"The Index of Learning Styles is an instrument designed to assess preferences on the four dimensions of the Felder-Silverman leaning style model" (Felder & Spurlin, 2005, p. 103). The dimensions are actually continuous scales summarised as:

- Active/reflective: Active learners retain and understand information by applying, reflective learners through thinking and processing.
- Sensing/intuitive: Sensing learners work with facts and problem solving, intuitive learners discover possibilities and innovate.
- Visual/verbal: Visual learners remember what they see, verbal learners what they hear.
- Sequential/global: Sequential learners reach understanding through logical linear steps, global learners see large amounts of information and move to solving complex problems quickly.

Learners display characteristics of each anchor of a dimension, with a strength of preference toward one end or the other of the scale. The 44-question instrument contains 11 a-b choice items for each scale. For scoring and statistical analysis, the "a" responses are counted to give each participant a number on the scale representing a preference for each dimension from 0 and 1 as strong in one direction, 2 and 3 moderate in that direction, through 4 to 7 mild either way, 8 and 9 moderate in the other direction, down to 10 and 11 as strong in that other direction.

Over the time of its usage, the Learning Style Index has been completed "hundreds of thousands of times per year and has been used in a number of published studies, some of which include data reflecting on the reliability and validity of the instrument" (Felder & Spurlin, 2005, p. 103). The test-retest reliability study of Gaughran et al. (2006) reported high correlations and statistical significance in reported scores of engineering students after a 4-week gap (see also Livesay et al., 2002; Zwymo, 2003). Zwymo (2003) also performed an exploratory factor analysis on the internal consistency reliability of the Learning Style Index using a sample with N = 551 undergraduate engineering students to investigate the homogeneity of the items proposed to measure each dimension. Using Cronbach's alpha as a measure of reliability when the measure is a preference, Tuckman (1999) suggested that a value for alpha of greater than 0.5 was acceptable in educational research, because it is an "indication of the extent to which the test measures stable and enduring characteristics of the test taker rather than variable and temporary ones" (p. 198). Using this value, Zwymo used the Kaiser criterion, the scree plot test to extract five factors, and then applied oblique rotation to identify the first three dimensions as high loading factors, with the fourth – sequential/global – having shared items with sensing/intuitive. In addition, Pearson correlation coefficients correlated by Zwymo (2003) and others (e.g., Livesay el al., 2002; Van Zwanenberg et al., 2000) all returned small r values, leading her to conclude that the dimensions were considered independent, except for again some small degree of correlation with sensing/intuitive and sequential/global. Based on the subsequent factor analysis of Litzinger et al. (2005), 4 of the 44 items of the index were found not to load well onto any of the factors. Although consideration was given to the removal of these items, the 4 scales by 11 items structure of the instrument ensures participants register comparable responses for each dimension. Further, the Cronbach alpha values for reliability of the instrument would not be significantly improved via removal of items. Felder and Spurlin concluded that the "association [found] is consistent with the theory that underlies the Index of Learning Styles and does not compromise the validity of the instrument for its principal intended purpose of designing balanced instruction" (p. 110, 2005).

4.6.3 Dependent variables

4.6.3.1 Test scores

The learning outcomes assessment (Appendix 4) consisted of 14 questions (8 application and 6 theory) where participants were required to identify values for elements of the TVM formula, perform calculations applying the content covered and examples given in the GLE or video, make decisions about optimal choices, and show evidence of understanding definitions and content. The assessment part of the experiment was consistent with assessing the learning objectives for TVM taught using traditional textbook and tables methods, drawing questions from the end of chapter questions common to these. In addition, the pre-test question was posed again to measure any change in understanding.

4.6.3.2 eGameFlow factors

The eGameFlow survey adapted from Fu et al. (2009) final iteration for this research (Appendix 5) was administered after the GLE, and required participants to rate their experience on a 5-point Likert scale (with 0 = *strongly disagree*, 1= *somewhat disagree*, 2 = *neutral*, 3 = *somewhat agree*, 4 = *strongly agree*) via agreement to a number of statements for each of the factors of:

- Concentration (5 items): Attention is focused. The game activities support concentration while minimising cognitive overload.
- Goal clarity (4 items): Tasks are clearly explained at the start of the game.
- Feedback (3 items): At various stages in the learning process information is provided which scaffolds learning and movement to higher levels.

- Challenge (5 items): Game activities are matched to skill level and increase in difficulty, requiring mental effort for success.
- Autonomy (3 items): Players have the ability and permission within the game mechanics to make their own decision providing opportunities for initiative and control.
- Immersion (5 items): Investment in the story and outcome is achieved via the deep mental involvement of being in flow.
- Knowledge improvement (5 items): The game increases knowledge and skills in line with curriculum.

For the control group, the word "game" was replaced by "video" to retain the comparability, in the sense of the learning experience, for within and between the control and the experiment groups. From their longitudinal critical review of studies employing factor analysis, Ford et al. (1986) put forward a number of recommendations for judicious factor analysis technique which would ensure the "validity of the information obtained from applied factor analysis research" (p. 311). In particular these recommendations include relating the "the factor model … to the goal of the research", and interpreting the factors "based on a knowledge of the variables" (p. 311). Adhering to this advice, and following on from the literature review, the eGameFlow factors corresponded with the hypothesised constructs being measured (Gray, 2014) and for hypothesis testing, the seven factors were grouped as follows, noting that some factors appear in more than one group:

(1) engagement – concentration, challenge, autonomy, and immersion. Recall from Section 2.4.1.1, Features that lead to gamification and support learning; Engagement, the effect of engagement is the measure of success the gamified learning components have on the learner through immersive content and challenging progress opportunities, while retaining interest and control (e.g., Shulman, 2002);

(2) performance – goal clarity, feedback, challenge, and knowledge improvement. Recall from Section 2.4.6, Taxonomy of learning outcomes, that providing the tools for learners to activate their intellectual ability to know and organise ideas, is achieved using clear goals, and active learning opportunities of challenge coupled with timely feedback (e.g., Biggs & Collis, 1982; Bloom, 1956; Boud & Associates, 2010; Churches, 2009). These factors may be measured as potential antecedents or contributing positive experiences towards improved performance; and

(3) self-efficacy - concentration, goal clarity, feedback, challenge, autonomy, and knowledge improvement. Recall from Section 2.4.1.2, Features that lead to gamification and support learning: Motivation, self-determination theory (Ryan & Deci, 2000), goal setting, real time feedback, transparency, and mastery are all motivators challenges learners to go beyond the content to become self-directed and achieving learning objectives in a deep learning, embedded way (e.g., Biggs, 1987; Bandura, 1982).

Table 6 in Section 3.4.1, Hypothesised model for testing, expands on the measurement instruments, and items and factors within the instruments, employed for each hypothesis.

4.7 Data analysis techniques and methods

The various techniques used in the data analysis are described in this section. The techniques included data screening and re-coding, factor analysis of the items contained in the eGameFlow survey, and hypotheses statistical tests using multivariate analysis of variance (ANOVA), otherwise known as MANOVA.

4.7.1 Data screening and re-coding

Data was retrieved as a SCORM file, scored, numerically coded from descriptive dropdown box answers, multiple choice answers and Likert responses, and entered into Excel for import into SPSS. To ensure accuracy of data prior to analysis, index of learning style scoring sheets were randomly checked against data entered into Excel file, then the original SCORM file data was proofread alongside the SPSS data window, as advised by Tabachnick and Fidell (2014) for small sample sizes. Valid range checks were performed by examining the frequency tables. Boxplots did not reveal any obvious outliers in the data. Bar charts were produced to assess normality of distributions. Descriptive statistics using means, standard deviations, and measures for skewness were inspected for each coded variable.

4.7.2 Validity and reliability of measures

4.7.2.1 Validity analysis

The validity of a measure is the extent to which it measures what it sets out to measure. There are three types of validity: content, criterion-related, and construct.

Content validity is the extent to which the instrument is representative of all the facets of the construct it is purporting to measure. The literature review sought to delineate construct dimensions and define operational definitions for the development of a measurement instrument. During this process, Fu et al.'s (2009) eGameFlow survey was identified as an appropriate instrument measuring the same concepts and was adapted for use in this research. The instrument had been previously validated (see Section 3.4.2.1, eGameFlow factors).

Criterion validity is established through comparison with another measure. It is further broken down into: "concurrent validity [which] refers to a measure's correlation with a known criterion measure collected at the same time, [and] predictive validity [which] is the ability of a measure to predict a criterion at some future point in time" (Rudy & Rudy, 2007). Owing to an absence of other known measures, and the iterative nature of the measure being adapted for this research, criterion validity was not a focus.

Construct validity is "the extent to which the measure 'behaves' in a way consistent with theoretical hypotheses and represents how well scores on the instrument are indicative of the theoretical construct" (Hays & Reeve, 2017, p. 246). For this research, factor analysis, consistent with Fu et al.'s (2009) validation technique for the original instrument, was used for construct validation.

4.7.2.2 Factor analysis

Exploratory factor analysis was used in this research to show the underlying relationships between measured variables of the original instrument, about which minimal empirical knowledge was known. Hair et al. (1998) suggest a sample size for factor analysis of at least 50, preferably 100, with a recommendation for a minimum multiplier of 5 observations per variable. With a sample size of n = 67 and 30 items in the instrument as variables, applying factor analysis to check the overall structure of the factors within the existing survey was not prudent and would "risk 'overfitting' the data [by] deriving factors that were sample specific with little generalizability" (Hair et al., 1998, p 99). It was, however, possible to analyse the existing factors individually, with their items ranging from three to five, to show that the suggested items all loaded onto that one factor.

This research used principal-axis factoring, as used by Fu et al. (2009), to extract and retain factors with an eigenvalue greater than 1, and orthogonal rotation using the varimax method to produce the maximised correlation matrices, and confirm that only one factor was extracted for each dimension of the original survey. To make the factor analysis observed correlation matrix easier to interpret the factors are rotated, and orthogonal rotation produces a loading matrix of observed variables and factor correlations. The size of the observed variables, the loading factor, is the strength of their relationship with the factor and each variable's loading factor contributes to the factor score, being a weighted sum of all the variables' contributions (Tabachnick & Fidell, 2014). The construction of scales for each factor then involves the unweighted summation of the mean scores for each substantial loading item in the factor. "[F]actor loadings greater than .3 are considered to meet the minimal level" (Hair et al., 1998, p. 111), and substantial for interpretation being represented as a minimum factor loading of .32 (Tabachnick & Fidell, 2014, p. 702).

Fu et al. (2009), in creating and refining the eGameFlow survey instrument, had tested its test structural validity using factor analysis. To confirm the validity of the instrument that has not yet been widely used or tested, this research repeated the procedure, using their same parameters, before data analysis was carried out, and extracted the factors of the eGameFlow survey instrument. In summary, the exploratory factor analysis applied to the eGameFlow data set prepared and examined the correlation matrix for correlations between each pair of variables and between the variables and the factor. Exploratory factor analysis confirmed the items for each factor loaded onto that one factor satisfactorily using eigenvalues of greater than 1. Observation and interpretation of the factor scores indicated how well the items loaded onto each factor for the retained factors. The factors contained varying numbers of items, therefore for comparison, scales were created using the mean of the items to represent each factor.

4.7.2.3 Reliability analysis

For independent variables, Tuckman (1999) found a reliability coefficient alpha value of .5 satisfactory in educational research. All items of each scale in the eGameFlow survey were reduced to their mean score and examined to determine if any items could be removed to strengthen the reliability of that scale.

4.8 Multivariate ANOVA and parameter assumptions

This research required the determination of any significance differences between the two independent groups, the control and the treatment group, on more than one continuous dependent variable – the learning assessment and the eGameFlow survey factors. Because each hypothesis had multiple dependent variable measures the best choice of statistical method for testing was a multivariate ANOVA. ANOVA because there was one fixed factor – the treatment. Multivariate ANOVA is an omnibus, or generalised test, where multiple explanatory variables contribute to the overall variance between the two groups. Specifically, whether the explained variance is significantly greater than the unexplained variance, or whether:

> [M]ean differences among groups on a combination of [dependent variables] are likely to have occurred by chance [and] by measuring several [dependent variables] instead of only one [as in ANOVA], the researcher improves the chance of discovering what it is that changes as a result of different treatments and their interactions. (Tabachnick & Fidell, 2014, p. 285)

In this way, multivariate analysis of variance (MANOVA) is preferable to comparing a series of dependent variable averages in a paired samples t-test and it therefore reduces the likelihood of Type 1 error by discovering correlation of dependent variables (Tabachnick & Fidell, 2014). The MANOVA model best represents the hypotheses to be tested.

In order to make accurate predictions about the relationship between the independent variable and the dependent variables, the sample data is used estimate the parameters in the total population from which it is drawn; that is how well it represents the actual population. Assumptions about the parameters must be met before data is analysed using MANOVA to ensure accurate, valid, and reliable results and interpretations. The assumptions relate to "additivity and linearity; normality …; homoscedasticity/homogeneity of variance; [and] independence" (Field, 2018, p. 230). When working with real data it is not unlikely that some assumptions will be violated; however, there are procedures to allow for these in interpretation. The MANOVA assumptions are detailed as follows:

Assumption 1. Two or more continuous dependent variables: The dependent variables of the eGameFlow factors are reported on a Likert scale (i.e., an ordinal scale but frequently treated as interval data in analyses) and learning assessment results are on an interval scale.

Assumption 2. The independent variable is two or more independent groups: The data was collected from a control and a treatment group.

Assumption 3. Independence of observations: No research participants were members of both groups.

Assumption 4. Adequate sample size: There were more cases in each group than the number of dependent variables being analysed.

Assumption 5. No univariate or multivariate outliers: To identify any multivariate outliers using the Mahalanobis distance measure. Using SPSS, this test identifies multivariate outliers by calculating a probability variable for each observation and prior to running multivariate inferential analysis, any instances where the new probability variable is less than .001 indicate multivariate outliers that should be removed. The Mahalanobis distance for each member of the total sample was calculated for each hypothesis: that is using the dependent variables to be measured to make assumptions about each hypothesis. In all three, the same member of the total data set collected was identified as a multivariate outlier returning a probability variable of less than .001. An examination of the raw data for this data set member revealed they had clicked a straight line of responses to each of the four survey parts. In addition, an examination of the time taken to respond to each item was minimal: in the range of 1 to 2 seconds for even the calculation learning assessment questions and questions that took longer than that amount of time to read. For these reasons, this data set member's data was considered a multivariate outlier and removed from the sample prior to analysis, as indicated in Section 4.5: Sample description.

Assumption 6. Multivariate normality: "Multivariate normality is the assumption that each variable and all linear combinations of the variables are normally distributed" (Tabachnick & Fidell, 2014) and it follows the residuals of the variables will be independent and normally distributed. Field (2018) says for normality, "when testing whether two means are different, the data do not need to be normally distributed, but the differences between the means does" (p. 233). Because violation of normality makes any statistical inference from the data less robust, transformation of the variables to improve normality is recommended (Tabachnick & Fidell, 2014).

Using SPSS each individual dependent variable was tested using the Shapiro-Wilk test for normality. The Shapiro-Wilk test is considered appropriate for small sample sizes of less than 30, and Kolmorgorov-Smirnov for sample sizes greater than 30. If the value of the appropriate test is below .05 it is regarded as significant. However, George and Mallery (2010) consider all normality tests are too sensitive to sample size, and they suggest graphical methods to best evaluate normality, along with tests for skewness (where the data tail right or left is too long) and kurtosis (the height or flatness of the data curve), with conservative alpha values being acceptable for small sample sizes: values between -2 and +2 being considered acceptable in order to prove normal univariate distribution (George & Mallery, 2010).

Descriptive and exploratory tests of the data in SPSS revealed all eGameFlow factors, with the exception of the autonomy factor, were skewed in the same positive direction and to approximately the same extent. This was the case for all but the autonomy factor item 3. For this item (1 of 3 items in this factor), an examination of the raw data showed that many participants in both groups responded strongly disagree to Item A3: I took the opportunity to repeat stages of the game/video. The resultant graphical representation was seen to be more evenly distributed across all response choices, with a peak at the negative end of the graph.

To improve the accuracy of predictability of analysis, data transformation is sometimes recommended (Field, 2018, Tabachnick & Fidell, 2014). Because the scale data is arbitrary for each of the eGameFlow factors, that is, preferences are recorded on a numeric Likert-scale, transformation of the data did however render the data difficult to interpret. Also, because all variables, with the exception of the autonomy factor as noted, were skewed in the same direction and to about the same extent, improvements gained for analysis after transformation were likely to be small. Taking all of this into account, SPSS was used to test the different transformations prior to actual transformation, to determine the effect of the potential transformation using the Levene’s statistic. Although the Levene’s statistic is used to test for significance of differences in homogeneity of variance, since transforming the data simultaneously tackles and corrects for normal distribution and unequal variances (Field, 2018), it follows that, if one assumption has been improved, the other will also have been improved. Data transformation by way of logarithm was chosen to be tested first because it can correct for positive (right tail) skew (and unequal variances, see assumption 8). Proposed log transformation improved the data for all factors to some extent. Reciprocal transformation, can also correct for positive skew (large numbers) and unequal variances. Data transformation by way of reciprocity also showed some improvement, but not to as great an extent as log transformation. As a result, the data was transformed to create a new variable by way of logarithm. This was followed by a further transformation and another new variable for the reflected logarithmic variable created in the first instance. Both new variables for each factor were then tested for skewness and kurtosis. The first transformation of natural log was found to have improved the normal distribution of the data sufficiently. In order to retain consistency in interpretation, the new variables were reverse scored. Note that, since transformation of the data was undertaken by log, the hypotheses would now be tested using the geometric mean of the factor scales.

Assumption 7. Additivity and linearity: A linear relationship between each pair of dependent variables for each group of independent variables shows a straight-line relationship between each pair and ensures that all data can be included in analysis. An examination of the scatterplot matrix for each dependent variable showed a linear relationship for each of the eGameFlow instrument factors and the learning assessment test.

Assumption 8. Homogeneity of variances: Homogeneity of variance/covariance matrices establishes how much variability changes across the data set; the assumption of homogeneity of variance being that all groups in the comparison have the same variance The most common assessment for homogeneity of variance – the least sensitive to non-normality – Levene's statistic, was used to test the assumption of variance calculated for the variables of two or more groups and examine any deviations from homogeneity of variance. The factors of feedback, autonomy, and immersion were all initially found to fail this assumption; that is, the *p* values were less than .05. Log transformation of the data to improve the relationship between the variables for analysis, carried out at Assumption 6: Multivariate normality, also improved the quality of the data in terms of homogeneity of variance. However, of note, ANOVA utilises the *F* statistic, which is generally robust to violations of the assumption as long as group sizes are equal. Equal group sizes may be defined by the ratio of the largest to smallest group being less than 1.5 (Field, 2018). The sample sizes of the independent variables are 27 and 40, control and treatment group respectively, and are therefore considered equal. The assumption of homogeneity of variance can be regarded as fulfilled.

Assumption 9. No multicollinearity. No dependent variable in the model can be linearly predicted from the others with a substantial degree of accuracy; that is, they are all measuring substantially different dimensions. When the initial multivariate ANOVA tests for each hypothesis were run, the dependent variables were found to be only moderately correlated, in the acceptable mid-range. Bivariate correlations between the eGameFlow dimensions were rather high but all less than the .7 cutoff suggested by Tabachnick and Fidell (2014). These findings were also in line with Fu et al. (2009) and Shu-Hui et al. (2018), who found that the scales still demonstrate convergent discriminatory validity.

In addition, the collinearity diagnostics were examined. Variance inflation factors were less than 10 (Hair et al., 1998). Condition indexes were all less than 30 and combined with variance proportions of less than .5 (Tabachnick & Fidell, 2014). No potential problems were found.

4.9 Summary

This chapter provided an overview of the choice of research methods and instruments employed for data collection, measurement of key variables, and data analysis. It described the implementation of the GLE experiment, and the collection, validation of data, and the sample description. The next chapter examines the results and analysis of data gathered from the qualitative and quantitative methods; learner questionnaire, learning outcomes, survey, follow up interviews, and discussion board.

Chapter 5 – Results and Analysis

5.1 Introduction

The previous chapter provided an overview of the choice of research methods and instruments employed for data collection, measurement of key variables, and data analysis. It described the implementation of the GLE experiment, and the collection, validation of data, and the sample description. This chapter examines the results and analysis of data gathered from the qualitative and quantitative methods; learner questionnaire, learning outcomes, survey, follow up interviews, and discussion board. Due to unexpected insignificant results from the initial analysis, a secondary analysis was performed which focused the investigation on the survey items pertaining to testing the learning experience within the GLE, not testing the game itself. This resulted in the refined ***eLearningGameFlow*** survey instrument being distilled. ***eLearningGameFlow*** is now a survey instrument with a purely educational focus. Items that had no distinguishing features around the learner's experience – that is items measuring the performance of the game features only – were removed and it now consists only of the items that measure the experience of participant's learning within the game. Factor and reliability analysis were carried out on this refined survey. Using ***eLearningGameFlow***, hypothesis testing for impact of the GLE on the learning experience was performed using MANOVA. There was a ***significant effect*** of the gamified learning experience treatment on overall learning experience/engagement regarding the technical threshold concept of TVM.

5.2 Demographics control variables

The demographic data collected provided the categorical control variables: gender, online/on campus, domestic/international, level of study, major, previous experience, level of confidence. An examination of the composition of the two groups, shown Table 8 below, shows a good random distribution across all control variables and between control and treatment groups. Paired sample *t*-tests were used to compare the means of the two independent groups to determine whether there was any statistical evidence that the population means were significantly different. The bivariate Pearson correlation test was used to measure the strength and direction of linear relationships between pairs of continuous variables in the sample. The correlation coefficient (*r*) evaluates whether there is statistical evidence to indicate a linear relationship among the same pairs of variables in the population. The independent samples *t*-test and the Pearson correlation test are parametric measures: they make assumptions about the normal distribution of the population the sample comes from and therefore adequately model the population. Because of the unequal distribution of final valid participant numbers across the groups, it was determined that using multivariate ANOVA, controlling for the independent variable of control or treatment group, would allow for comparison between the groups.

Table 8 Descriptive statistics for control variables within Control and Treatment groups (Part a)

Control variable	Description	Total	Control		Treatment		Pearson Chi-square	*p*-value
		n	*n*	Percent within group	*n*	Percent within group		
Gender[a]	Male	30	10	37.0	20	50.0	1.095	.295
	Female	37	17	63.0	20	50.0		
Study mode	On campus	50	23	85.2	27	67.5	2.663	.103
	Online	17	4	14.8	13	32.5		
Student type	Domestic	33	10	37.0	23	57.5	2.700	.100
	International	34	17	63.0	17	42.5		
Study level	Associate degree	2	0	0	2	5.0	9.185	.057
	Bachelors	32	11	40.7	21	52.5		
	Honors	22	14	51.9	8	20.0		
	Masters	10	2	7.4	8	20.0		
	Doctoral	1	0	0	1	2.5		
Major	Business	19	6	22.2	13	32.5	8.861	.115
	Accounting	34	19	70.4	15	37.5		
	Finance	1	0	0	1	2.5		
	Admin/Management	3	1	3.7	2	5.0		
	Law	4	0	0	4	10.0		
	Other	6	1	3.7	5	12.5		
Studied TMV before	Yes	37	16	59.3	21	52.5	.298	.585
	No	30	11	40.7	19	47.5		

Note. [a] No participants identified as Other.

Demographic information collected on the control variables for age and the four Felder Silverman learning style dimensions, provided scale data. As detailed in Table 9 the age of participants ranged from 18 to 57 years for the Control group and 19 to 68 years for the treatment group. The learning styles were reported on a scale of 0 – 5 as detailed below. Comparing the means, standard deviations, and corresponding *t*-tests and *p*-values for each of dependent variables, no significant differences between and among the participant makeup of the control and treatment groups were revealed. The *t*-test standardised statistic compares the means of two independent groups to determine if there is a significant difference between the means of two groups. With the value set at 0.05, there were no significant differences found between the two groups: all absolute *t*-test values being greater than 0.05. The *p*-value is the probability of observing a result at least as great as the observed results in the data. Again, with the value set at 0.05, no effect was observed in any of the variables, that is, no significant differences were observed in the dispersion of results between the two groups: all *p*-values being greater than 0.05. Therefore, it can be assumed that any differences between groups on the dependent variables are not due to significant differences in the make-up or original knowledge of the two groups.

Table 9 Descriptive statistics for control variables within Control and Treatment groups (Part b)

Control variable		Mean	Standard deviation	Minimum	Maximum	*t*-test	*p*-value
Age	Control	33.70	12.359	18	57	.501	.618
	Treatment	32.18	12.159	19	68		
Learning style dimension:							
Active/reflective	Control	2.667	1.1435	0	5	1.396	.168
	Treatment	2.325	.8590	1	4		
Sensing/intuitive	Control	1.593	1.1522	0	4	.617	.539
	Treatment	1.400	1.3166	0	5		
Visual/verbal	Control	1.482	1.0874	0	4	.937	.371

Control variable		Mean	Standard deviation	Minimum	Maximum	*t*-test	*p*-value
	Treatment	1.725	1.0858	0	4		
Sequential/global	Control	1.704	.9533	0	4	-1.886	.065
	Treatment	2.175	1.0350	0	4		

5.2.1 Index of learning styles control variables

Prior to the GLE participants completed the Felder Silverman Index of Learning styles: a set of 44 binary questions (Appendix 3). A scoring sheet was used to collate each participant's responses to the survey questions: 11 questions related to each of 4 learning dimensions: active/reflective, sensing/intuitive, visual/verbal, and sequential/global. These scores were tabled on the scale for each dimension from 0-11: 0-1 and 2-3 *strong* to *moderate* at one end of the dimension, 4-5 and 6-7 *mild* either way, 8-9 and 10-11 *moderate* to *strong* at the other end of the dimension. The bands were then coded 0 to 5 for input and analysis in SPSS. Table 10 shows an example of the Learning Styles Index Report of Results for Participant E24.

Table 10 Learning Styles Index Report for Participant E24

Dimension	Strong (5)	Moderate (4)	Mild ← (3)	Mild → (2)	Moderate (1)	Strong (0)	Dimension
Active				X			Reflective
Sensing	X						Intuitive
Visual			X				Verbal
Sequential		X					Global

5.2.2 Learning Styles Index as a secondary independent variable

The purpose of administering the Felder-Silverman Index of Learning Styles pre-survey was to collect data to test to determine there were no significant differences on any of the dimensions between the control and treatment groups. The treatment design was created using universal design for learning principles and adhering to all the elements of the Felder-Silverman learning styles (Section 2.4.3.2, Table 2). This ensured that there would be no advantage to any specific learner preferences with the GLE for the purpose of the research, and more broadly for the ultimate purpose of learning.

5.3 eGameFlow dependent variables: Factor and reliability analysis

Factor and reliability analysis were detailed in Section 4.7.2. Because of sample size limitations it was not possible to check the overall structure of the factors within the survey, but each factor could be analysed to confirm that the suggested items all loaded onto that one factor. Fu et al. (2009) used principal-axis factoring to test structural validity and extract the factors of the eGameFlow survey instrument. Consistent with their tests, this research extracted factors with an eigenvalue greater than 1 and with varimax orthogonal rotation of > 0.4 as the benchmark to make factor selections.

5.3.1 Exploratory factor analysis

Table 11 summarises the key measures for the eGameFlow survey instrument factor analysis. With eigenvalue > 1 all items loaded on to one factor.

Table 11 Key measures for factor analysis

Factor	KMO	Eigenvalue > 1	% of variance explained	Cronbach's alpha
Concentration	.761	1	54.553	.768[a]
Goal clarity	.579	1	60.577	.776
Feedback	.649	1	67.624	.752
Challenge	.855	1	67.704	.876
Autonomy	.598	1	54.242	.543
Immersion	.810	1	68.207	.882
Knowledge improvement	.699	1	54.428	.777

Note. Potential increase in Cronbach's alpha by removal of items a Concentration 1: .814

5.3.1.1 Concentration

Table 11 above shows for concentration, a Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy of .76, which is well above the .5 benchmark used by Hair et al., (1998), and Tuckman (1999) as a useful indicator of the proportion of variance in the variables that might be caused by underlying factors. This was quantified by the percentage of explained variance, 54.55%. All items loaded onto one factor. The concentration factor matrix below (Table 12) shows the individual item loading with no loadings below the benchmark of .3 (Hair et al., 1998, Tabachnick & Fidell, 2014). Cronbach's alpha was .77. It could have been increased to .81 with the removal of item Concentration 1[a]; however, the incremental gain in reliability was small and the item's factor loading was above the benchmark of .3, so to retain the original nature of the eGameFlow survey, where Fu et al. (2009) found this item to load at .6, the item was retained.

Table 12 Concentration factor matrix

Item number	Description	Factor loading
Concentration 3	I was not distracted from the learning task.	.783
Concentration 4	I was not burdened by taks that seemed unrelated.	.780
Concentration 2	I remained focused on the game.	.770
Concentration 5	The workload of the game was adequate.	.595
Concentration 1	The gaming activities are related to the learning task.	.308[a]

5.3.1.2 Goal clarity

Table 11 above shows for goal clarity, a KMO measure of sampling adequacy of .579, which was above the .5 benchmark used by Hair et al., (1998) and Tuckman (1999). The percentage of explained variance was 60.58%. The concentration factor matrix below (Table 13) shows the individual item loading with no loadings below the benchmark of .3 (Hair et al., 1998, Tabachnick & Fidell, 2014). Cronbach's alpha was .78.

Table 13 Goal clarity factor matrix

Item number	Description	Factor loading
Goal clarity 4	Intermediate goals were clear.	.892
Goal clarity 3	Intermediate goals were presented at the beginning of each scene.	.839
Goal clarity 2	Game goals were clear.	.615
Goal clarity 1	Game goals were presented at the beginning of the game.	.573

5.3.1.3 Feedback

Table 11 above shows for feedback, a KMO measure of sampling adequacy of .649, which was above the .5 benchmark (Hair et al, 1998; Tuckman, 1999). The percentage of explained variance was 67.62%. The concentration factor matrix below (Table 14) shows the individual item loading with no loadings below the benchmark of .3 (Hair et al., 1998, Tabachnich & Fidell, 2014). Cronbach's alpha was .75.

Table 14 Feedback factor matrix

Item number	Description	Factor loading
Feedback 2	I received immediate feedback on my actions.	.907
Feedback 1	I received feedback on my progress in the game.	.678
Feedback 3	I was notified of new tasks immediately.	.580

5.3.1.4 Challenge

Table 11 above shows for challenge, a KMO measure of sampling adequacy of .855, which was well above the .5 benchmark (Hair et al., 1998, Tuckman, 1999). The percentage of explained variance was 67.70%. The concentration factor matrix below (Table 15) shows the individual item loading with no loadings below the benchmark of .3 (Hair et al., 1998, Tabachnich & Fidell, 2014). Cronbach's alpha was .88.

Table 15 **Challenge factor matrix**

Item number	Description	Factor loading
Challenge 5	The game provided different levels of challenges tailored to my needs.	.866
Challenge 3	The difficulty of challenges increased as my knowledge improved.	.795
Challenge 2	The game provided other supports to help me with the challenges.	.775
Challenge 4	The game provided new challenges at an appropriate pace.	.715
Challenge 1	The game provided hints that helped me with the challenges.	.707

5.3.1.5 Autonomy

Table 11 above shows, for autonomy, a KMO measure of sampling adequacy of .60, which was above the .5 benchmark (Hair et al., 1998; Tuckman, 1999). The percentage of explained variance was 50.24%. The concentration factor matrix below (Table 16) shows the individual item loading with no loadings below the benchmark of .3 (Hair et al., 1998, Tabachnich & Fidell, 2014). Cronbach's alpha was .54.

Table 16 **Autonomy factor matrix**

Item number	Description	Factor loading
Autonomy 1	I felt a sense of control and impact over the game.	.788
Autonomy 3	I used the opportunity to repeat stages of the game.	.461
Autonomy 2	I understood the stages of the game.	.457

5.3.1.6 Immersion

Table 11 above shows, for immersion, a KMO measure of sampling adequacy of .81, which was well above the .5 benchmark (Hair et al., 1998; Tuckman). The percentage of explained variance was 68.21%. The concentration factor matrix below (Table 17) shows the individual item loading with no loadings below the benchmark of .3 (Hair et al, 1998, Tabachnich & Fidell, 2014). Cronbach's alpha was .88.

Table 17 Immersion factor matrix

Item number	Description	Factor loading
Immersion 3	I temporarily forgot about other things while I played the game.	.902
Immersion 5	I felt emotionally involved in the game.	.781
Immersion 4	I became involved in the game.	.770
Immersion 2	I became unaware of my surroundings while I played the game.	.746
Immersion 1	I forgot about time passing while I played the game.	.679

5.3.1.7 Knowledge improvement

Table 11 above shows for, knowledge improvement, a KMO measure of sampling adequacy of .70, which was well above the .5 benchmark used by Hair, Anderson, Tatham, and Black (1998). The percentage of explained variance was 54.43%. The concentration factor matrix below (Table 18) shows the individual item loading with no loadings below the benchmark of .3 (Hair et al, 1998, Tabachnich & Fidell, 2014). Cronbach's alpha was .78.

Table 18 Knowledge improvement factor matrix

Item number	Description	Factor loading
Knowledge improvement 4	The game motivated me to integrate my knowledge straight away.	.837
Knowledge improvement 3	I applied my knowledge within the game.	.835
Knowledge improvement 5	I want to know more about the concept taught in the game.	.719
Knowledge improvement 2	I understood the basic idea of the game straight away.	.458
Knowledge improvement 1	The game increased my knowledge.	.394

In summary, factor analysis showed that the items loaded onto the factors extracted and used by Fu et al. (2009). With the reliability of each of the factors established, participant scale scores were created for each factor using the means of the items on the scale.

5.4 Learning outcomes assessment dependent variable

Learning outcomes were coded against an answer sheet. These items consisted of eight application of learning questions and six multiple-choice theory questions and were grouped for further investigation: questions 1-6 application, questions 7-12 theory, and questions 13 and 14 application. Using SPPS to compute the independent samples *t*-test for equality of means between the control and treatment groups, no significant differences in the total correct values of the learning outcomes assessment or the subsets of application and theory questions were found. Results are shown in Table 19.

Table 19 Descriptive statistics for learning outcomes assessment (Appendix 4) dependent variable within Control and Treatment groups

Learning outcomes assessment		Mean	Standard deviation	Min	Max	*t*-test	*p*-value	Pearson Chi-square	*p*-value
Total correct/14	Control	10.00	2.909	2	14	-0.038	.970	6.070	0.869
	Treatment	10.03	2.412	5	14				
Application questions/8	Control	5.778	1.968	1	8	-0.386	.701	10.514	0.062
	Treatment	5.95	1.663	2	8				
Theory questions/6	Control	4.222	1.281	1	6	0.567	.572	4.019	0.778
	Treatment	4.050	1.176	2	6				

Figure 19 graphically compares the total correct values for the control and treatment groups. Although statistically not significant, as above, visual inspection of the results shows a *shrinking* of the tail in the treatment group, with no students scoring below 5. This corresponds to Carini et al.'s (2006) work that showed making learning activities more engaging had some interesting characteristics on learning outcomes frequency distributions. They showed that the tail of failures (mostly the "Roberts" [Biggs & Tang, 2007]) for a cohort would shrink up towards the Pass mark. The median grade (or mark) would improve a moderate amount and shift the centre of the bell curve (where reside a majority of students including mostly "Roberts") into higher grades. The number of students already in the higher-grade levels did not change so much, as those students (the "Susans" [Biggs & Tang, 2007]) were already engaged with learning. The imposition of engaging learning activities skewed the marks frequency distribution towards higher marks, and this is visually apparent to some extent in this research data.

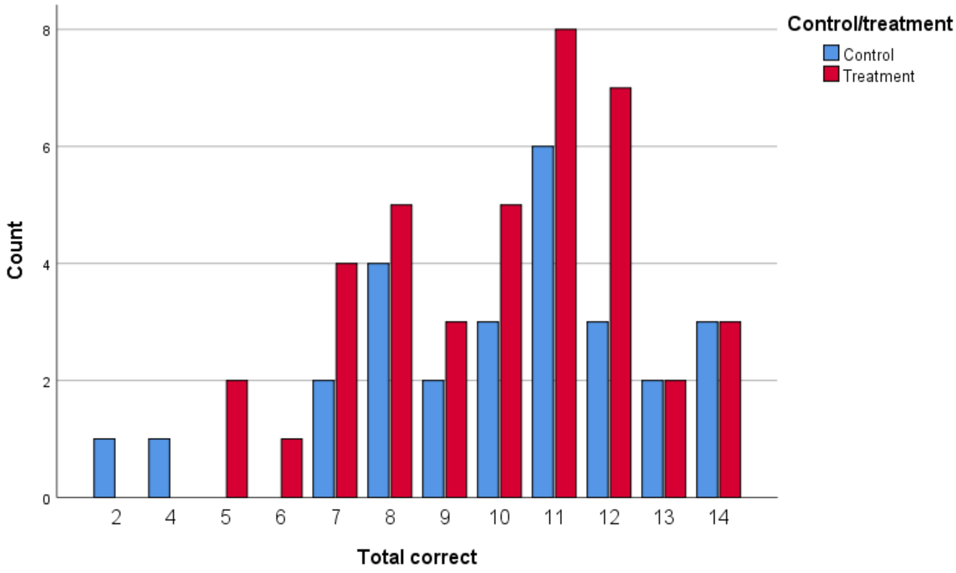


Figure 19 Total correct in learning outcomes assessment by Control and Treatment groups

Note. Control: N = 27, Median = 11, Mode = 11; Treatment: N = 40, Median = 10.5, Mode 11; Total: N = 67, Median = 11, Mode = 11

5.4.1 Pre/post-testing

In the initial demographic data collection, participants were asked a pre-test question on the TVM concept of future value. For comparison, the same question was included in the learning outcomes assessment after the learning experience, as a post-test question. No significant differences were found pre-test/post-test correct for the control or treatment groups (Control pre-test 22/27, post-test 25/27; Treatment pre-test 32/40, post-test 36/40). This indicates the test for understanding of TVM may not have been sufficiently sensitive to detect differences in understanding. Alternatively, it could indicate that the participants were not lacking in understanding of the concept prior to the intervention, creating a ceiling effect in the data.

The data collected post-test was also compared to data available from historical undergraduate and post graduate samples (Table 20), where the same question was administered in a comparable online quiz environment, post learning, and not under invigilated conditions. Tests of differences did not reveal any significant differences.

Table 20 Treatment post-test comparison to historical samples

Sample descpription	Incorrect	Correct	Total	Percentage	*Z*-value
Undergraduate A 2014	2	14	16	87.5	-0.432
Undergraduate A 2015	4	19	23	82.6	-1.111
Undergraduate A 2016	1	15	16	93.8	0.350
Post graduate A 2018	1	20	21	95.2	0.620
Post graduate B 2018	0	8	8	100	0.882
Post graduate A 2019	3	30	33	91.1	-0.022
Post graduate B 2019	0	8	8	100	0.822
Control post-test	2	25	27	90.1	
Treatment post-test	4	36	40	92.6	
Experiment total post-test	6	61	67	91.0	

Note. Shaded rows represent sample data $N = 67$

Data was also extracted to calculate the time spent by each participant on pre-test and post-test questions. No difference was found between treatment and control groups on pre-test time (Mann-Whitney $U = 326.5$, $p = 0.077$), post-test time (Mann-Whitney $U = 368.0$, $p = 0.249$), or pre-test time minus post-test time (Mann-Whitney $U = 403.5$, $p = 0.533$). However, a Wilcoxon signed-rank test showed that post-test times were faster than pre-test times for the full sample ($Z = -4.886$, $p < 0.001$). The full sample median pre-test time was 93 seconds, while the median post-test time was 27 seconds. Although the accuracy of this result cannot be verified as the experiment was not conducted under conditions which controlled for extraneous time usage variables, the Wilcoxon statistic deals with outliers, such as those which would result from uncontrolled and variable time usage, by recognising them as cases that rank one above or below the next less extreme case. Therefore, the result suggests that, on the whole, participants were able to answer the question faster after the learning experience than before, perhaps indicating greater understanding and confidence after exposure to any learning experience.

5.5 Hypotheses testing and analysis of results

5.5.1 Hypothesis 1: Engagement

For testing of Hypothesis 1, a 2 x 2 between-subjects multivariate ANOVA was performed on the four dependent variables related to engagement: concentration, challenge, autonomy, and immersion. Independent variables were the control and treatment groups. SPSS General Linear Model MANOVA was used for the analyses with descriptive statistics and $p < .05$. The independent variables were entered in the contrast order of control followed by treatment. The total N was 67, after adjustment for multivariate outliers at $p < .01$ and detailed in Section 4.8: Multivariate ANOVA and parameter assumptions. All other evaluations from assumption testing for normality, homogeneity of variances, linearity, and multicollinearity were fulfilled. Because there were no missing values, each of the multivariate F tests (Pillai's trace, Wilks' lambda, Hotelling's trace, and Roy's largest root) returned the same exact result, therefore just Pillai's trace is reported, as it is generally used for when sample sizes are equal and is considered most robust (Field, 2018). Using Pillai's trace, "the sum of the proportion of the explained variance on the discriminant function" (Field, 2018, p. 640) on the combined dependent variables is transformed into an approximate F value distribution. The MANOVA showed **no significant effect** of the gamified learning experience treatment on engagement with the technical threshold concept of TVM, $V = 0.13$, $F(4, 62) = 2.36$, $p = 0.06$. The subsequent univariate ANOVA results for the dependent variables confirmed that the treatment had not had a significant impact on participant engagement: concentration, $F(1, 65) = 0.21$, $p = 0.65$;

challenge, $F(1, 65) = 0.48$, $p = 0.49$; autonomy, $F(1, 65) = 2.07$, $p = 0.16$; and immersion $F(1, 65) = 2.83$, $p = 0.08$.

5.5.2 Hypothesis 2: Learning outcomes

For testing of Hypothesis 2, a 2 x 2 between-subjects multivariate ANOVA was performed on the five dependent variables related to performance of learning outcomes: goal clarity, feedback, challenge, and knowledge improvement. Independent variables were the control and treatment groups. SPSS General Linear Model MANOVA was used for the analyses with descriptive statistics and $p < .05$. The independent variables were entered in the contrast order of control followed by treatment. The total N was 67. As per the previous hypothesis' test, Pillai's trace is the only multivariate F test reported in this section. Using Pillai's trace, there was **no significant effect** of the gamified learning experience treatment on performance of the technical threshold concept of TVM, $V = 0.16$, $F(5, 61) = 2.31$, $p = 0.06$. The subsequent univariate ANOVA results for the dependent variables confirmed that the treatment had not had a significant impact on participant performance: learning outcomes, $F(1, 65) = 0.001$, $p = 0.98$; goal clarity, $F(1, 65) = 2.39$, $p = 0.13$; feedback, $F(1, 65) = 1.16$, $p = 0.29$; challenge, $F(1, 65) = 0.48$, $p = 0.49$; and knowledge improvement $F(1, 65) = 0.000003$, $p = 1.00$.

As disclosed in Section 5.4, Learning outcomes assessment dependent variable, there was also no significant difference in the learning outcomes assessment of the two groups. Further as per the selection of factors for hypotheses testing in Section 3.4.2.1 eGameFlow factors, these factors may only collectively be measured as potential antecedents or contributing positive experiences towards improved performance not measuring learning improvement itself. In particular the goal clarity, feedback, and challenge factors may affect students' ability to attain learning outcomes, but knowledge improvement is the only real indicator or measure of improved performance. In the univariate analysis, looking at the results for the knowledge improvement factor alone to test Hypothesis 2 does not show a significant result ($F(1, 65) = 0.000003$, $p = 1.00$): further illustrating that the correlations of the dependent variable factors is where the power to affect significance within the multivariate ANOVA testing resides.

5.5.3 Hypothesis 3: Self-efficacy

For testing of Hypothesis 3, a 2 x 2 between-subjects multivariate ANOVA was performed on the six dependent variables related to self-efficacy: concentration, goal clarity, feedback, challenge, autonomy, and knowledge improvement. Independent variables were the control and treatment groups. SPSS General Linear Model MANOVA was used for the analyses with descriptive statistics and $p < .05$. The independent variables were entered in the contrast order of control followed by treatment. The total N was 67. As per the previous hypotheses' tests, Pillai's trace is the only multivariate *F*-test reported in this section. The MANOVA showed there was a **significant effect** of the gamified learning experience treatment on self-efficacy regarding the technical threshold concept of TVM, $V = 0.19$, $F(6, 60) = 2.47$, $p = 0.03$. The subsequent univariate ANOVA results for the dependent variables returned the following statistics: concentration, $F(1, 65) = 0.21$, $p = 0.65$; goal clarity, $F(1, 65) = 2.39$, $p = 0.13$; feedback, $F(1, 65) = 1.16$, $p = 0.29$; challenge, $F(1, 65) = 0.48$, $p = 0.49$; autonomy, $F(1, 65) = 2.07$, $p = 0.16$, and knowledge improvement $F(1, 65) = 0.000003$, $p = 1.00$.

In this case, the multivariate test statistics showed a significant effect of the treatment on the dependent variables for the self-efficacy hypothesis, but an examination of the subsequent univariate ANOVA results would seem to indicate that the treatment had not been successful in creating a significant impact. This phenomenon is due to the power of the multivariate ANOVA accounting for correlations between the dependent variables and detecting effects of the group as a whole. To more closely examine and interpret the interaction of the dependent variables, and determine which of the dependent variables contribute most to the group separation, discriminant function analysis was carried out. Using unstandardised function coefficients and selecting for separate-groups covariance, a single discriminant function was disclosed, because there are only two groups (control and treatment) (Kinnear

& Gray, 2004). Therefore, the single function results significantly differentiated the groups, Wilks' Lambda Λ = 0.80, chi-square $x^2(6) = 13.66$, and as per MANOVA, $p = .03$. From the structure matrix (Table 21), the correlations of the outcome discriminating variables and the discriminant functions revealed that the factors of goal clarity ($r = 0.39$) and autonomy ($r = 0.36$) loaded highest, and quite evenly onto the function.

Table 21 Structure matrix: Hypothesis 3

Dependent variable factor	Variate correlation coefficient
Goal clarity	.386
Autonomy	.360
Feedback	-.269
Challenge	.172
Concentration	-.115
Knowledge improvement	.001

Note. Variables ordered by absolute size of correlation within function

5.6 Qualitative findings

Feedback progress indicators (Section 2.4.9, Table 3, Jones et al., 2014) were utilised to prompt discussion board threads, and to inform questions for follow up interviews to extract exit poll qualitative data.

5.6.1.1 Discussion board

The discussion board invited participants to comment on the following questions:

1. What you liked - or not?
2. What worked best for you - or not?
3. What you would like to see changed or different?
4. Any other feedback?

A total of 12 participants used the discussion board 13 times. Typical of the feedback were the posts from the following students:

> The quiz was very informative, and the layout and instructions were easy to follow. The content was presented clearly and was interactive, and the problem math questions were creative and short. The maths concepts were challenging however, I feel confident to apply these to future finances. (Participant MM)

> I am glad that finally someone [is] asking about what makes it easier to learn or how to present materials. It was very informative, short and succinct. As an international student with English as my second or even third language, I personally prefer pictures and diagram to learn new concepts. It is quite challenging and time consuming to go through the whole text, we have to convert sometimes to our own language and then figure out what is the message of text, whereas, material presented by diagram, chart, etc. We would like to learn something that leads us to final answer. (Participant AM)

Another participant when reflecting on the comparison between his learning experience in the two groups commented:

> I found this [control group] a little better experience because I knew what to expect. So being familiar with the process made it easier to go through and focus more. Even though I did several emails along the way. In group 2 [control group] the questions were more ambiguous and so I had more wrong than right. (Participant PK)

This participant completed the treatment GLE first and then did the control version (data from this control version was not included in the analysis sample N = 67). The interesting observation here is that the assessment questions to which he refers were exactly the same in both the treatment and control groups, and yet after having experienced the content twice he was less efficacious and performed worse after the control version.

5.6.1.2 Follow-up interviews

Follow-up interviews allow for exploration and narrative insight into the experiences of the participants to expand on the findings of the research (Gray, 2014). Analysis of the quantitative data revealed a number of areas where further description and story behind the participants' actions within the experiment would give the research more effect. Therefore, questions were included that encouraged participants to reflect on their learning experience within the GLE and the longitudinal influence it had on their knowledge and confidence of the threshold concept taught, as well as the comparison of both learning activities. The questions also specifically identified and asked participants to comment on elements of the game that were either unable to be included (live leader board) or unable to be measured (pathway through the game and repeats), to gather data about the potential effect of these enhancements for future GLE design. The four participants chosen to represent the characteristics of the sample were deidentified and labelled: JP – female, domestic, undergraduate, EL – male, domestic, undergraduate; NH – male, international, undergraduate; and AS – male, international, undergraduate).The follow-up interviews followed a general interview guide approach (Valenzuela & Shrivastava, n.d.) using a set of questions (1 to 8 below) in a conversational approach ensuring that the same general areas of information were collected, while still allowing the interviewee freedom to reflect on and express other thoughts related to the experience.

1. How do you think the game worked with your learning preferences?
2. Did you repeat any levels of the game? (H1 Engagement and H2 Performance)

3. Would a live leader board have influenced the way you played the game? (H1 Engagement and H2 Performance)
4. What do you think your level of confidence with TMV is now? (H3 Self-efficacy)
5. Have you used your knowledge of TVM in any other learning scenarios? (H3 Self-efficacy)
6. Can you think if you've used what you learned to help your understanding of any current media events? (H3 Self-efficacy)
7. How would you compare your experience and learning between the two groups: the video and the game?
8. Is there anything else you'd like to tell me?

Although there were only a small number of interviews to analyse, a visual representation in keeping with the premise of this research was sought. The interviews were therefore transcribed and transformed (Wolcott, 2009) using Leximancer – a text mining software which recognises document content, looks explicitly for common word patterns, and creates a visual display of the extracted information using a concept map. The extraction stage classifies and groups common terms for multiple concepts to provide an overview of the material and predict whether a small segment of text contains one or more of the concepts. It then gives a name to each concept as a signpost to allow for ease of interpretation and visual representation of the main concepts and how they are related (Smith & Humphreys, 2006). Whilst Leximancer actually calls these word patterns themes, they are **not actually *themes*** in the interpretive sense, where meanings are revealed. They are syntactic and therefore the use of ***common term*** is adopted throughout this research. The common terms represent "groups or clusters of concepts that have some commonality or connectedness [and is illustrated by] their close proximity on the Concept Map", concepts are groups of words that "travel together in the text", and connectedness is the summed co-occurrence with all other concepts (Leximancer, n.d.). From this transformation, seven common terms were identified in the interviewees' answers to the questions. These terms are ranked in Table 22. The ranking is based solely on syntactic analysis, or parsing, which breaks down the component parts of sentences to attribute *logical* meaning and make sense. Here it shows that, for example *process* was accompanied by its concept words more often than the other common terms.

Table 22 Distilled common terms

Common term	Hits	Concepts	Word-like relevancy
Process	26	Process, whole, game, sequential, video, cause, better, learned, started, obviously, tracked, hints, wrong	45%
Time	8	Knew, time, tracked, wrong	73%
Probably	6	Probably, answer, try	55%
Real	4	Real	36%
Doing	4	Doing, look	36%
Finance	4	Finance, used, time value of money	36%
Able	3	Able	27%

Hits are the collective number of times concepts appear in the narrative being examined, allowing for the ranking of the common terms. The Leximancer algorithm starts with the top ranked common term and creates a common term group centred on the top concept. Some concepts will appear in other common term groups. Prevalence is the number of concepts in a common term. A high word-like relevancy percentage word may not be frequent, but when it appears it will be other strong words. (Leximancer, n.d.).

This process of discovering common terms using concepts allows for more analysis and interpretation of the transcribed text than an examination of word count frequency, because the strength of the relationships of groups or words are revealed. This is further illustrated by the concept map (Figure 20). In the centre of the map is the highest ranked common term bubble, “process”, with its accompanying concepts (whole, game, sequential, video, cause, better, learned, started, obviously, hints). The next-highest, ranked common terms, “time” (concepts: knew, tracked, wrong) and “probably” (concepts: answer and try), are linearly connected and positioned close to "process" and near the centre of the map. Lesser ranked common terms with fewer concepts, "real", "doing", and "finance" are represented by progressively smaller bubbles and positioned further from the centre. "Able", with the least hits, is shown near the common terms it appeared with and partially overshadowed by them.

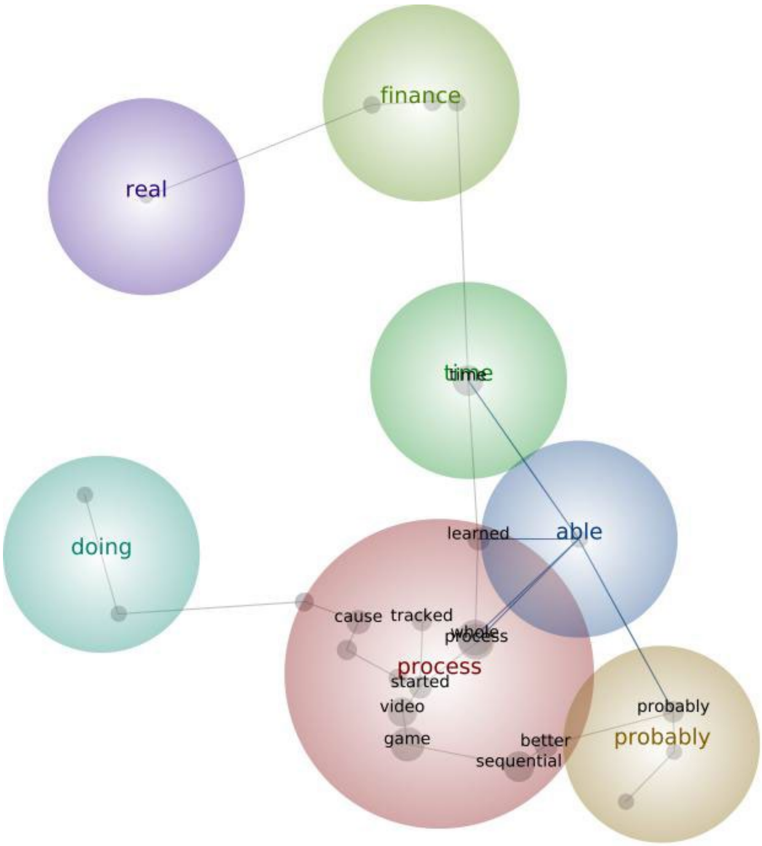


Figure 20 **Concept map of document analysis**

Analysis of the synopses used by the Leximancer algorithm to identify common terms further revealed the following comments from follow up interview participants, in support of each hypothesis:

Hypothesis 1: Engagement with learning

Q1: How do you think the game worked with your learning preferences?

> [W]ith the video – you got side tracked a lot easier. The mere fact that you were following step by step in the game and you answered questions as you go along. I preferred that as sequential instead of just watching the whole video and then answering questions. (Participant NH)

Q7: How would you compare your experience and learning between the two groups: the video and the game?

> The game … kept me focused because I have to actively participate to progress. (Participant EL)

Hypothesis 2: Performance of learning outcomes

Q2: Did you repeat any levels of the game?

> I think I did [repeat a level] cause I think I ticked something wrong and I had to go back and double check my, what I'd either read wrong or rushed and didn't do it completely correctly. So, it is good that you can actually back track and have a quick look where you went wrong to fix your problem and then continue through. Being able to see and do and practice at the same time. (Participant JP)

Q3: Would a live leader board have influenced the way you played the game?

> Possibly maybe a leader board of the top 10 only cause you don't want to discourage lower scoring students, but definitely I think with the leader board I would have been more persuaded to go back and redone it. (Participant NH)

> For me yes, because that's just me. I like to see how I'm tracking. That to me would help. Being able to see

> where I am in the scheme of things out of the many. (Participant JP)

> I even worked in the sales, so when you have those numbers and you are checking it every hour and you have to get a certain number so it's like a numbers game so when you can see that it's like okay I'll go back and do it again. (Participant AS)

Hypothesis 3: Self-efficacy

Q2: Did you repeat any levels of the game?

> That was the first time I'd done TVM. I used the same TVM when I was studying business finance, I was a bit more active when I was studying. In class I was like I know that thing. It's really important to know TVM like today you have $10 what's it going to be worth in 10 years, because of the inflation and changes. (Participant AS)

Q6: Can you think if you've used what you learned to help your understanding of any current media events?

> [TVM]'s relevant in a lot of different things and you'll always come back to it as a foundation. (Participant NH)

5.7 Development of eLearningGameFlow

Because of the unexpected insignificant results for Hypotheses 1 and 2 from the initial analysis, the eGameFlow survey instrument was re-examined with a purely educational goal in mind. It was decided to remove any items that had no distinguishing features around the learner's experience – that is items measuring the performance of the game features only – and perform a secondary analysis using only the items that measured the experience of participant's learning within the game. The revised table of items is shown in

Table 23. The number of factors has been decreased from seven to four, with the removal of Goal Clarity, Feedback, and Knowledge Improvement. The number of items has also been decreased in two of the remaining factors. Two items were removed from the Concentration factor, and 4 from the Challenge factor. The decisions on which items, and therefore three whole factors, to remove was based on the language of the items. Items with the game as the focus were removed and items with the learner as the focus were retained. For example, items removed included: “Game goals were clear” (Goal Clarity - G2), “I received feedback on my progress in the game” (Feedback – F1), and “I understood the basic idea of the game straight away” (Knowledge Improvement – K2). These are all items which ask the learner to assess the game. In contrast, retained items included: “I was not distracted from the learning task: (Concentration – C3), and “The difficulty of challenges increased as my knowledge improved” (Challenge – H3). These are items that ask the learner to consider their learning experience within the game. This in no way detracts from the usefulness of eGameFlow as a learning game design survey, but rather refines it to a game learning survey. This new survey, ***eLearningGameFlow***, aims to test learning and learner elements, aligning game flow with learning flow.

Table 23 **eLearningGameFlow survey**

Factor	Item number	Content
centration	C2	I remained focused on the game
	C3	I was not distracted from the learning task
	C4	I was not burdened by tasks that seemed unrelated
Challenge	H3	The difficulty of challenges increased as my knowledge improved
Autonomy	A1	I felt a sense of control and impact over the game
	A2	I understood the stages of the game
	A3[a]	I used the opportunity to repeat stages of the game
Immersion	I1	I forgot about time passing while I played the game
	I2	I became unaware of my surrounding while I played the game
	I3	I temporarily forgot about other things while playing the game
	I4	I became involved in the game
	I5	I felt emotionally involved in the game

When entering the eGameFlow results, it was observed that participants in both groups mostly answered strongly disagree for question A3: Did you take the opportunity to repeat stages of the game/video? Secondary investigation with follow up interviews addressed this specifically and typical responses were, "Nup. I kind of knew time value of money anyway so …" (Participant EL) and "I think I just went for the straight through approach but I did notice you could go back" (Participant NH). However, this item was retained as it still reflects the learner experience. The disinclination to repeat stages of the game more likely indicating that students who volunteered in this research were already motivated and engaged with their own learning.

5.7.1 eLearningGameFlow factor and reliability analysis

As per the exploratory factor analysis detailed in Section 4.7.2.2, the new survey was tested to extract factors with an Eigenvalue greater than 1 and with varimax orthogonal rotation of > 0.4 as the benchmark to make factor selections. Table 24 summarises the key measures for the eLearningGameFlow survey instrument factor analysis. With Eigenvalue greater than 1 all items loaded on to one factor.

Table 24 **Key measures for eLearningGameFlow factor analysis**

Factor	KMO	Eigenvalue > 1	% of variance explained	Cronbach's alpha
Concentration	.711	1	74.683	.829
Challenge[a]	na	na	na	na
Autonomy[b]	.598	1	54.242	.543
Immersion[b]	.810	1	68.207	.882

Note. [a] Challenge factor statistics are not calculated or reported as only 1 item remains for this factor in eLearningGameFlow. [b] No items were removed from Autonomy or Immersion factors, therefore statistics reported as per original eGameFlow factor analysis (Table 11).

The items retained in the new Concentration factor were actually the top 3 loading items from the original eGameFlow survey factor analysis. The change in items increased the Cronbach's alpha to .829 from .77, with no potential for increase through removal if any items. The reduction in the number of items still only extracted one factor with an Eigenvalue of greater than 1, but the variance explained was increased to 74.683% (up from 54.55%). KMO sampling adequacy was still above .7, at .711, but a slightly reduced from .76. This is most likely explained due to the smaller number of items. The new Concentration factor matrix below (Table 25) shows the individual item loading with no loadings below the benchmark of .3 (Hair et al., 1998, Tabachnich & Fidell, 2014).

Table 25 **New concentration factor matrix**

Item number	Description	Factor loading
Concentration 3	I was not distracted from the learning task.	.889
Concentration 2	I remained focused on the game.	.870
Concentration 4	I was not burdened by taks that seemed unrelated.	.833

5.7.2 Hypothesis testing and analysis of results using eLearningGameFlow

When the data from eGameFlow was measured for validity and reliability (Section 4.7.2.1, Validity and reliability of measures), it was tested to ensure it met the assumptions about the parameters before it was analysed using MANOVA to ensure accurate, valid, and reliable results and interpretation. During this process the data was transformed by way of logarithm to improve the normal distribution and achieve more robust results. This was done by computing a variable which was a calculation of the mean of each factor, transforming by the natural log, then reverse scoring for consistency.

In order to compare the results of hypotheses testing using eLearningGameFlow to the original eGameFlow factors, transformation of the eLearningGameFlow factors was investigated. In eLearningGameFlow the number of items in the concentration and challenge factors were reduced, resulting in zeros in the mean scores of some data sets. This occurred because the SPSS coding scale is 0-4 and examination of the actual data revealed that some participants answered the retained items, all at the zero end. The meant that these variables couldn't be transformed via logarithm without adding a constant and even then, it's unpredictable as the transformed data moves progressively further away from the original data. Also, adding a constant to one variable requires adding a constant to all the others for the purposes of MANOVA, thereby compounding the situation where eLearningGameFlow hypothesis testing would not use the same variables as the original hypothesis analysis anyway. Field (2019) asserts that there is not conclusive agreement on whether transformation significantly improves the robustness of the *F*-statistic anyway, and "given the issues, unless correcting for lack of linearity [to] use robust procedures, where possible in preference to transforming the data" (p. 270). The data was visually examined for consistency and the MANOVA tests were run in SPSS with untransformed factor means, using the new concentration and challenge factors.

For testing of the eLearningGameFlow survey's impact on overall learning experience, a 2 x 2 between-subjects multivariate ANOVA was performed on the four dependent variables of the new survey: concentration, challenge, autonomy, and immersion. These are also the same four dependent variables of eGameFlow used to test Hypothesis 1: Engagement, with the removal of items as indicated above from the concentration and challenge factors. Independent variables were the control and treatment groups. SPSS General Linear Model MANOVA was used for the analyses with descriptive statistics and $p < .05$. The independent variables were entered in the contrast order of control followed by treatment. The total N was 67, after adjustment for multivariate outliers at $p < .01$ and detailed in Section 4.8: Multivariate ANOVA and parameter assumptions. All other evaluations from assumption testing for normality, homogeneity of variances, linearity, and multicollinearity were fulfilled. As per the previous hypotheses' tests, Pillai's trace is the only multivariate F-test reported in this section. The MANOVA showed there was a **significant effect** of the gamified learning experience treatment on overall learning experience/engagement regarding the technical threshold concept of TVM, $V = 0.164$, $F(4, 62) = 3.036$, $p = 0.024$. The subsequent univariate ANOVA results for the dependent variables returned the following statistics: new concentration, $F(1, 65) = 0.75$, $p = 0.39$; new challenge, $F(1, 65) = 0.176$, $p = 0.677$; autonomy, $F(1, 65) = 1.032$, $p = 0.313$, and immersion $F(1, 65) = 5.153$, $p = .027$.

In this case, the multivariate test statistics showed a significant effect of the treatment on the dependent variables of the eLearningGameFlow, but an examination of the subsequent univariate ANOVA results would seem to indicate that the treatment had only been successful in creating a significant impact on the immersion factor ($p = .027$). As stated above, this phenomenon is due to the power of the multivariate ANOVA accounting for correlations between the dependent variables and detecting effects of the group as a whole. Discriminant function analysis was carried out to examine and interpret the interaction of the dependent variables, and determine which of the dependent variables contributed most to the group separation. Using unstandardised function coefficients and selecting for separate-groups covariance, a single discriminant function was disclosed. Therefore, the single function results significantly differentiated the groups, Wilks' Lambda Λ = 0.836, chi-square $x^2(4) = 11.27$, and as per MANOVA, $p = .024$. From the structure matrix (Table 26), the correlations of the outcome discriminating variables and the discriminant functions confirmed that the factor of Immersion ($r = 0.636$) loaded highest, indicating the substantive nature of this variable. Autonomy ($r = -0.285$) and Concentration ($r = 0.243$) loaded quite evenly onto the function, and the single-item Challenge factor ($r = -0.117$) followed, indicating it had the smallest contribution to group separation.

Table 26 eLearningGameFlow structure matrix - Hypothesis 1: Engagement

Dependent variable factor	Variate correlation coefficient
Immersion	.636
Autonomy	-.285
New Concentration	.243
New Challenge	-.117

Note. Factors tested match H1: Engagement in eGameFlow, but are also the full complement of factors and items in eLearningGameFlow, that is the entire survey being tested for MANOVA. Variables ordered by absolute size of correlation within function.

5.8 Summary

This chapter examined the results and detailed the analysis of data gathered from the qualitative and quantitative methods; demographics, learner questionnaire, learning outcomes, survey, follow up interviews, and discussion board. The refined **eLearningGameFlow survey** instrument was distilled from secondary analysis of the data. The next chapter, Chapter 6: Discussion, discusses reported demographics and learning preferences, and considers their influence on the learning outcome results. Multivariate ANOVA interpretation then examines the correlations to learning outcome results to make inferences about learner engagement, learning success, and self-efficacy.

Chapter 6 – Discussion

6.1 Introduction

The previous chapter described the implementation of the gamified learning experience (GLE) experiment, and the collection and analysis of data gathered from the qualitative and quantitative methods; demographics, learner questionnaire, learning outcomes, survey, follow up interviews, and discussion board. The refined **eLearningGameFlow survey** was developed and described. This chapter discusses the reported demographics and learning preferences of research participants and considers the influence of these on the learning experience and outcome results. Multivariate ANOVA interpretation then examines the correlations to learning experience and outcome results to make inferences about the hypotheses of learner engagement, learning success, and self-efficacy. This multivariate ANOVA method and the GLE design framework are used to evaluate the use of the GLE treatment as a pedagogical resource in accounting and finance technical threshold concepts. However, subsequent investigation of the initial results and the survey factors used to measure the hypotheses led the researcher to reconsider the items that comprised each factor and determine which of those were actually *measuring the student* and which were *measuring the system*. This ultimately led to the distillation of a new subset survey – eLearningGameFlow – containing only items that were learner centred. Multivariate ANOVA used this new survey to test for the impact of the GLE. Contributions and limitations of the research are enumerated and discussed.

6.2 Overview of experiment

The experiment applied the pedagogy of a GLE using a plot driven narrative to illustrate and carry the content of time value of money (TVM), to facilitate student learning of an accounting and finance technical threshold concept. The potential and intrinsic value of a positive learner relationship with the GLE was identified in the literature (Marklund & Taylor, 2016). The GLE situated the learner in an authentic exercise (Lucas & Mladenovic, 2009) using scaffolded challenges requiring the learner to use reasoning abilities to put the threshold concept principle of TVM into practice in real time. To demonstrate the resolution of troublesome threshold concepts and development of critical thinking skills of an accountant (Meyer & Land, 2006), TVM was chosen as it is ubiquitous across all accounting and finance curricula (Dempsey, 2003). This research developed, contrasted, and evaluated the effectiveness of the gamification of teaching and learning, and assessing TVM.

6.2.1 Research questions

Revisiting Section 1.5, the original guiding research questions were:

1. How can a gamified learning experience enhance student engagement in learning about technical threshold concepts of accounting and finance?

2. How can a gamified learning experience enhance student learning outcomes in technical threshold concepts of accounting and finance?

3. How can the enactment of the principles and framework of gamification in the delivery of technical threshold concepts in accounting and finance enhance student self-efficacy?

4. How can the enactment of the principles and framework of gamification contribute to the learning design for the teaching of technical threshold concepts in accounting and finance?

6.2.2 Summary of methods used to investigate the research questions

Using an experimental research method, research participants were randomly assigned to either a control or an experiment group, and the results of the application of the treatment compared (Creswell, 2011; Gray, 2014). Cross tabulations and Pearson's chi-squared values of the demographic data were examined and revealed no significant differences between and among the participant makeup of the control and treatment group. Comparison of means, standard deviations, and *t*-tests and corresponding *p*-values for each of the learning style index dependent variables, also revealed no significant differences between and among the participant makeup of the control and treatment groups. The research then measured participant experiences and outcomes (dependent variables) after the application of the treatment (independent variable), to test the hypotheses using qualitative observations and quantitative experimentation (Gray, 2014). Deductive quantitative measurement of survey responses and learning outcome assessments combined with textual analysis of the qualitative data gathered from discussion board posts and follow up interviews (Braun & Clarke, 2006) provided insight and answers to the research questions.

6.2.3 Major findings

The application of the treatment GLE on the population representative sample of participants in this study demonstrated a statistically **significant** correlation between participant self-efficacy with the threshold concept of TVM and the GLE, and a statistically **significant** correlation between engagement with the learning of the threshold concept of TVM in subsequent analysis, using eLearningGameFlow. The application of the treatment GLE did not produce a statistically significant correlation between assessed learning outcomes of the technical threshold concept of TVM and the GLE, but improved engagement of learning was suggested by the learning outcome marks' frequency distribution comparison between the two groups. Contrary to the hypothesised effects of a gamification curriculum to produce engaged, self-efficacious students who demonstrate increased levels of learning, this research suggests that while advantageous, perhaps gamification alone is not a panacea that the literature has pointed towards (e.g., Bedwell et al., 2012; Deterding, 2012; Kapp, 2016; Lameras et al., 2015). The findings therefore suggest that student engagement with gamified learning activities and game-based expressions of learning need to be considered in conjunction with other education design protocols (Bell, 2016; Kier, 2019; Zwymo, 2003) and overall curriculum design.

6.3 Research questions and discussion of results from hypotheses testing

6.3.1 GLE and engagement

Research question 1: How can a gamified learning experience enhance student engagement in learning about technical threshold concepts of accounting and finance?

H1: Gamification of the learning experience of the technical threshold concept TVM enhances learner engagement. **Initial test: *Rejected*. Subsequent test: *Accepted*.** (See Section 6.3.4: The emergence of eLearningGameFlow)

Initial multivariate ANOVA testing of results using all items of eGameFlow, indicated that the four engagement variables (concentration, challenge, autonomy, and immersion) as a group did not differ significantly between the control and the treatment groups. Contrary to the expected association, although the relationship was positive, this hypothesis was rejected in this first testing. The result contradicted the claims of Kapp (2016), who advocated the benefits of integration of GLE into curriculum for autonomous, self-directed learning, and the expectation that the use of GLE as a pedagogical resource, would foster intrinsic motivation (Appleton et al., 2008; Biggs, 1987) and provide the immersive experience of flow (Csikszentmihalyi, 1990). Recall from Section 2.3.3, flow, achieved through the mix of work and play, is the embodiment of focused concentration experience "during intrinsically interesting activities" (Hamari et al, 2015, p. 171) delivered via a plot-driven narrative. Immersion in the story of the plot driven narrative fosters the learner's desire to invest beyond the initial content through additional challenges and achieve deep understanding (Appleton et al., 2008). Finding no significant difference between the two groups was therefore unexpected given supporting literature and anecdotal evidence (e.g., Fu et al., 2009; Kapp, 2016). However, on closer inspection of the data and the sample, some possible reasons were identified relating to who the participants were and their potential motivations, and patterns in how some of the scaled eGameFlow items were answered.

The voluntary nature of the experiment, requiring participants to complete extra work on top of their student load, would have led to some self-selection sample bias. Students who volunteered to participate were likely already motivated and engaged with their own learning and prepared to do more to further their knowledge and understanding. The possible result was that whichever group they were allocated to, they were likely to engage with the content.

As previously examined in Section 5.7: Development of eLearningGameFlow, when entering the eGameFlow results, it was observed that participants in both groups mostly answered *strongly disagree* for question A3: Did you take the opportunity to repeat stages of the game/video? This again indicates that students who volunteered were already motivated and engaged with their own learning trajectory and likely to engage with the content in either group. Also given that if both sets of students were then similarly engaged, the learning outcomes would also be expected to be similar for both groups. Perhaps a more discriminating measure of engagement with learning was needed, in addition to, or to supplement, the eGameflow survey constructs.

Two other possible explanations for the non-significant result of the engagement hypothesis were considered. Small sample size, coupled with the abovementioned potential self-selection bias, may have acted to reduce the significance of the result. In addition, there was perhaps not enough contrast between the control and the treatment group in terms of the quality of the educational experience.

From a learning game design perspective, to increase engagement in a GLE, future versions would allow for more learner personalisation and more advanced game mechanics. The insightful comment of one interview participant also demonstrated the value of a “leaderboard of the top 10 only”, not just as a performance measure but a persuasive method of encouraging re-engagement to improve, while not discouraging engagement of learners who need to improve.

This research question and the corresponding engagement hypothesis are re-addressed in the subsequent **significant** finding with multivariate ANOVA testing using eLearningGameFlow in Section 5.7.2.

6.3.2 GLE and learning outcomes

Research question 2: How can a gamified learning experience enhance student learning outcomes in technical threshold concepts of accounting and finance?

H2: Gamification of the learning experience of the technical threshold concept TVM enhances learner performance. ***Rejected***.

Multivariate ANOVA indicated that the learning outcomes test scores and the four performance outcome variables (goal clarity, feedback, challenge, and knowledge improvement) as a group did not differ significantly between the control and the treatment groups. Testing the learning outcome scores was also not significant (Section 5.4, Learning outcomes assessment dependent variable). Although the results were in the expected direction, this hypothesis was rejected.

This result was contrary to Schoenau-Fog (2011), who reported that, in learner centred experiences, students engage with the challenging activities of exploration, critical analysis, and scaffolded problem solving to add to their schema of knowledge. Massoudi et al. (2017) also reported the potential for learning outcome improvement due to access to and use of online resources in general. Further, Beatson et al. (2019) reported that timely feedback and rewarded levels of development – such as those built into a GLE – contributed to future successful application of knowledge. Clearly explained tasks at the outset of the GLE guide the learner as they work towards a stated goal or quantifiable outcome (Crawford, 1982). Overarching all of this, the consideration of learner preferences (Felder & Silverman, 1988) in the universal design for learning (Gordon et al., 2011) approach to the holistic GLE learning design, created a learning experience designed to provide multiple means of representation the content for optimal learning for all students.

Similar to Hypothesis 1, the finding here of no significant difference between the two groups was surprising given the supporting literature and inferred evidence. Again, the voluntary nature of the experiment, with the requirement of extra work, would have led to some self-selection sample bias. Students who volunteered to participate were more likely to be high-achieving students who were self-directed and prepared to do more to achieve greater knowledge and understanding. In whichever group they found themselves, they were likely to perform well on a learning outcomes assessment. This conjecture was confirmed by one participant (NH) in a follow-up interview: “I did have a very good understanding from high school but it is always [good] to have the same thing shown in a different way”. However, the scaffolding and feedback in the GLE were the preferred method of delivery: “Following step by step in the game and [answering] questions as you go along. I preferred that … instead of just watching the whole video and then answering questions.”

As with Hypothesis 1, the two other possible explanations for the non-significant result of the learning performance hypothesis were assumed. Small sample size with potential self-selection bias, and lack of separation between the two groups, may have acted to reduce the significance of the result. However, the measurement of performance outcomes alone does not definitively show if “change occurs as a direct result of experience [within] a game” (Schrader & McCreery, 2012, p. 13). To ascertain causation, it is imperative to test for other non-assessment metrics including engagement and self-efficacy, and look at them as an interactive group.

This led to the consideration that some factors of this construct did not directly measure learning performance of the student. The only definitive measure of student learning performance, is in terms of measurable learning outcomes. Some of the factors may affect students’ ability to attain those outcomes (goal clarity, feedback, challenge), but the knowledge improvement is the only real indicator or measure of improved performance. Goal clarity, feedback, and challenge, contribute more to the design evolution and evaluation criteria for the gamified learning environment. However, consideration of the results with only knowledge improvement as a factor still failed to show a significant result, confirming that the treatment had not been successful in creating a significant impact. Again, this is likely due to the number of already engaged student participants, that is, a ceiling effect.

Learning outcomes are measured by what a student can do. At undergraduate level (AQF7) this is around application. This means that beyond knowledge there must be skills (problem solving, communicating, analysing, comparing, etc.) and the application of knowledge and skills. It would seem that the TVM GLE captures some but not all of these performance items.

Strategies to increase learner performance in future iterations of a more sophisticated GLE would be to include in-game assessment, the accumulation of points, and a live leaderboard. These were all indicated by the observations of the participants in the follow up interviews. Being able to see how they were "tracking", where they were in "the scheme of things", and being able to check progress, were all stated as useful future inclusions.

6.3.3 GLE and self-efficacy

Research question 3: How can the enactment of the principles and framework of gamification in the delivery of technical threshold concepts in accounting and finance enhance student self-efficacy?

H3: Gamification of the learning experience of the technical threshold concept TVM enhances learner perception of self-efficacy. ***Accepted***.

Multivariate ANOVA indicated that the six self-efficacy variables (concentration, goal clarity, feedback, challenge, autonomy, and knowledge improvement) as a group differed significantly between the control and the treatment groups at the 5% level. The relationship was positive and this hypothesis was accepted.

This result was interesting given that the first two hypotheses found no significance with different combinations of the same eGameFlow variables (concentration, goal clarity, feedback, challenge, autonomy, knowledge improvement). However, H1 and H2 involved few variables: H1 engagement – concentration, challenge, autonomy, immersion; and H2 performance outcomes – test scores, goal clarity, feedback, challenge, knowledge improvement). As a group, the H3 eGameFlow variables worked together to have a positive impact on learner perception of self-efficacy because self-efficacy is a function of more variables and “the multivariate test takes into account the correlation between all the dependent variables and has more power to detect group differences” (Field, 2013, p. 650). The discriminant function analysis (Section 5.5.3) actually shows the combination of the goal clarity and autonomy variables contributed most to the significance with their high and quite equal loading. Because they appear together as variables in H3 but only singly in the other hypotheses – autonomy in H1 and goal clarity in H2 – the strength of this combination, with the other variables, is key, and the result was significant. Therefore, it can be inferred from the results that the gamification of the technical threshold concept of TVM enhances the perception of self-efficacy and in particular the perception of autonomy and goal clarity, influences the sense of self-efficacy. This would appear to be so even with a population of “Susans” (Biggs & Tang, 2007), who while not exhibiting a significant difference in learning outcomes or engagement with learning, non the less showed increased self-efficacy.

This result was as expected because when troublesome knowledge is resolved through context and conceptual thinking, knowledge improves and confidence builds self-efficacy to deal with progressively harder challenges (Meyer & Land, 2006). Knowledge improvement was one of the eGameFlow factors measured in this hypothesis. Synonyms for confidence include assurance, self-reliance, support, and assertion, which cross reference to the autonomy and feedback factors measured for this hypothesis. The GLE also utilised the chunking principle of cognitive load theory (Miller, 1956; Sweller, 1998, 2002), which Mostyn (2012) showed was successful for introductory accounting, by optimising intrinsic load through goal clarity and exercising control over progression of the complexity of challenging content. The separation and sequencing of the interactive elements of a topic into a narrative, represented in multiple modes catered to diverse learners with various base level knowledge and rates of progression. The effective use of feedback and early achievement in the GLE through the reward of bonus points and levelling up and/or positive feedback in the early decision-making activities, allows the learner to progress (Bandura, 1982; Mason et al, 2016). Learners are motivated by showing them that their investment in the process is worthwhile. Fear of failure is reduced because of the opportunity to repeat levels and revisit clues without penalties, in an autonomous, self-paced, self-controlled anonymous environment. Clear expectations, goals, and parameters, coupled with immediate and continuous feedback, plus a sense of progress through the levels of the GLE is apparent. There is a clear pathway to future success (Beatson et al., 2019).

Although the testing showed a significant effect, consideration was also given as to how well the factors measured or related to student self-efficacy as opposed to learning environment attributes that should positively influence perceived self-efficacy. It was decided that where autonomy and knowledge improvement were measures of self-efficacy, the other four factors (concentration, goal clarity, feedback, and challenge) largely measured features of the system rather than pure student self-efficacy. For example, the use of feedback and early achievement opportunities, and the progression through more challenging levels of content, are system features that students are able to use and adapt to their learning needs to develop self-efficacy at their own pace. What is directly measurable, in terms of self-efficacy, is their perceived autonomy to learn at their own pace.

Self-efficacy was reported by interview participants. One international student reported being “more active when I was studying” and feeling “like I know that thing”. Another student recognised the value of surmounting this technical threshold concept because of its relevancy and being always able to “come back to it as a foundation”.

6.3.4 The emergence of eLearningGameFlow

After considering the results and possible contributors and distractors of the three hypotheses, the researcher was led to ponder the difference between design for gamers to learn versus design for learners, when in fact with the overlay of pedagogy the user becomes one and the same: no longer just a gamer but a gaming learner. Consequently, a smaller, more targeted survey emerged where the items and factors focused on the user as learner rather than just the gamer's interaction with the learning game. Where eGameFlow effectively measures parameters of the design for gamers to learn, eLearningGameFlow now measures the game's effect on the learner's overall learning experience.

The factors that informed each construct were considered to determine which were actually measuring the student and which were measuring the system. Items within the factors with the game as the focus were removed and items with the learner as the focus were retained (Table 23). The engagement factors (concentration, challenge, autonomy, and immersion) appeared most suitable and these matched the full complement of new revised item factors in eLearningGameFlow. For learning outcomes, only the revised challenge factor remained once items were removed. For self-efficacy, revised factors were concentration, challenge, and autonomy. The factor names were retained from eGameFlow for consistency, however, they are perhaps not as descriptive in the new survey with its reduced number of items, and the statistical analysis of the test as a whole.

6.3.4.1 eLearningGameFlow test: GLE and engagement revisited

Research question 1: How can a gamified learning experience enhance student engagement in learning about technical threshold concepts of accounting and finance?

H1: Gamification of the learning experience of the technical threshold concept TVM enhances learner engagement. Initial test: *Rejected*. **Subsequent test: *Accepted***.

As reported in Section 5.7.2, Hypothesis testing and analysis of results using eLearningGameFlow, delivered the expected result of a ***significant effect*** of the gamified learning experience treatment on overall learning experience regarding the technical threshold concept of TVM. When compared to the non-significant effect of the original engagement hypothesis testing which contained the same factors for analysis, it would appear that the reduction of items within the factors to just the learner focused items provided a more targeted measure of the value of the GLE. That is eLearningGameFlow now provides a way to test the learning experience within the learning game, as opposed to being measured in conjunction with the attributes of the game in eGameFlow. This new survey in no way detracts from the usefulness of eGameFlow as a *learning game design survey*, but rather refines the original survey to a *game learning survey*.

6.3.5 GLE and development of pedagogy

Research question 4: How can the enactment of the principles and framework of gamification contribute to the learning design for the teaching of technical threshold concepts in accounting and finance?

The principles and framework of gamification were operationalised in the GLE treatment and the results from the testing of the hypotheses of engagement, performance outcomes, and self-efficacy, provided insight into the development of pedagogy. Importantly, although only the one hypothesis of self-efficacy was significant, all three hypotheses findings together have something to contribute. The learning from this experiment can be expanded to approaches for assisting student learning with other threshold concepts - both in accounting and finance, and in other disciplines - and for learning more generally.

Self-efficacy within the GLE was generated through universal design for learning, where multiple means of representation and engagement where delivered for use by learners in a plot driven narrative for learning using a familiar interface, consistent with games design. Learner engagement was created in the GLE using context and relatability, that is involvement in the story, and the cognitive load theory principle of chunking the information into a small contained learning objective. Increased customisation and choices within the GLE would enhance the user experience and engagement. In addition, the expansion to a massive multi-player role play game would provide opportunities for social and peer learning to further develop the pedagogy. While there was no significant difference between the groups related to performance, it is proposed that this could be changed by the integration of assessment within the GLE – learning by doing – situating the learning with the assessment to actively embed the knowledge. This could be achieved via a more sophisticated GLE with game-based assessment with points throughout (Bell, 2016).

Tracing the development of the literature, it can be inferred from the results of the GLE treatment, that meeting the learners in a relatable way, that is by creating contextualised learning utilising the functionality of digital resources they use to conduct their lives, creates self-efficacy. Recall from Section 2.6.4, The threshold concept: Time value of money, admittance to either of the professional accounting registration bodies requires graduates not only to have a foundation of technical threshold concept knowledge, but also the critical thinking skills necessary to effectively apply such knowledge when they enter the profession and continue their lifelong learning and development as members of CPA Australia or CAANZ. Specifically, the required intellectual skills and confidence for problem solving, decision making, and the exercise of good judgement, constitute self-efficacy, and include:

- the ability to locate, obtain, organise and understand information from human, print and electronic sources
- the capacity for inquiry, research, logical and analytical thinking, powers of reasoning, and critical analysis

- the ability to identify and solve unstructured problems which may be in unfamiliar settings (https://www.cpaaustralia.com.au).

The results from the reduced item and factor, learner centred eLearningGameFlow confirmed that the GLE was successful in creating a significantly improved overall *experience of learning*. The significant finding in H3: Self efficacy with eGameFlow indicates that the scaffolded learning of the accounting and finance technical threshold concept TVM in the GLE can improve the learners' capacity to move from current level of knowledge, through the zone of proximal development threshold. They change from being not yet competent or able to complete a task independently, to a state where they can achieve tasks autonomously (Redd, 2012). They arrive at a place of self-efficacy. Beatson et al. (2019) showed the positive predictive effect of self-efficacy for future academic performance success in accounting. It follows that, if the GLE has uncovered the power to increase learners' self-efficacy, the longitudinal effect is for future learning performance to be increased.

It is, however, prudent to bear in mind when applying these tests that TVM may be a threshold concept for many students but not for all students. With the above declared self-selection bias by already engaged students, perhaps not all students went through that liminal state. So, is a threshold concept always a threshold concept? The answer may be yes, statistically, at a population level, but not so for all individuals.

The gamification pedagogy does add an additional method to the two traditional methods of teaching an accounting and finance technical threshold concept, that is teaching TVM using text examples or tables. It does this by mapping the same desired learning outcomes into the GLE but expanding the learning opportunities through active learning, decision making, immediate feedback, and game-based assessment. Further, the GLE extends the range of the learning activity, enables delivery, and stands in for the physical teacher through the considered use of digital technology.

6.4 Contributions

For this research, a technology enhanced accessible pedagogical resource, the **time value of money gamified learning experience**, was built using multiple means of representation and learner engagement to demonstrate gamification of the curriculum for a technical threshold concept. It was hypothesised that this would increase learner engagement, outcomes, and self-efficacy. Although initial analysis showed significant improvement in only self-efficacy, the GLE is nonetheless a valuable contribution to the knowledge and theory of learning, and learner interaction with content and modes of delivery, especially when the findings of the learner focused eLearningGameFlow survey are examined. Given that the hypotheses were derived from an extensive review of the literature that suggested there should be some significant influence of gamified learning then, even the negative findings of engagement and performance significance will contribute significantly to knowledge, providing the possible limitations are considered. There are still avenues to explore in the creation of contextual engaging GLEs and game-based assessment. However, the finding of increased self-efficacy in the treatment group showed the learners who experienced the GLE came away with a greater level of confidence of their knowledge of the content of the technical threshold concept, and a willingness to continue their own investigation of learning to broach other similar problems and more challenging examples. Belief in the ability "to learn and have control over their own outcomes … will promote [student's] motivation and increase their engagement with learning" (Evans et al., 2021, p. 3). It is therefore posited that increased self-efficacy achieved in a GLE can lead to increased engagement with content and demonstration of learning over a longer horizon. This is a demonstration of critical thought and application of knowledge beyond the original concept. The following contributions are now discussed:

- Contribution to literature on measurement of learning in gamified learning experiences
- Research design – eLearningGameFlow

- Theory – the Gamification Alignment Table and the Gamification Alignment Model
- Methodology – the Generalised Conversational Framework
- Learning design demonstrated using a validated structural design model

6.4.1 Literature review

The literature review conducted for this research indicates a comprehensive understanding of the current knowledge of the areas of threshold concepts in accounting and finance, learning design, and gamification of learning. A contribution to literature on measurement of learning in gamified learning experiences is made, in particular where the overlapping areas are considered. The initial non-significant findings of engagement with learning, and performance of learning, using eGameFlow, will contribute significantly to the knowledge of GLE design. This will direct future research attention to the design of the interaction points of the student experience of learning within the GLE. The reduced item and factor new survey, eLearningGameFlow, will assist with measurement and testing of this.

6.4.2 Research design

After data screening and validity and reliability testing, exploratory factor analysis was carried out on the eGameFlow survey factors retained by Fu et al, (2009). While six of the seven factors performed as expected, the computed Cronbach's alpha of the Concentration factor was .77. Analysis in SPSS found this could have been increased to .81 with the removal of item Concentration 1a. Because the incremental gain in reliability was small and the item's factor loading (.308) was still above the benchmark of .3, the item was retained to preserve the original nature of the eGameFlow survey. Fu et al. (2009) had found this item to load at .6. Upon further investigation into the composition of eGameFlow survey, it was considered that perhaps this item would better load onto another factor. In future uses of eGameFlow with larger data sample sets, the item in question: "The gaming activities are related to the learning task", could be included under the Goal Clarity factor, causing the survey to be reframed.

As described in Section 5.7, Development of eLearningGameFlow, a revised eGameFlow survey, has been developed through this research. **eLearningGameFlow** has a reduced number of items (12), and focuses on, and more precisely tests, the student experience of learning within a game, not just the features of a GLE that assist the student. The new form of the survey no longer has items under Fu et al.'s (2009) factors of Goal Clarity, Feedback, and Knowledge Improvement. All the items under these factors were removed as they were tests of the game not the learner experience. There is scope for future research to give consideration to any additional questions that would address these factors from the learner experience perspective, potentially improving eLearningGameFlow.

6.4.3 Theory

A **gamification alignment table** (Section 3.2.2) was created to link the pedagogical and gaming terminologies coupling the elements and language of gaming against curriculum components. Equating the lexicons allows an encourages learning designers and educators to think of how the GLE can function in an educational context. From this vocabulary alignment and through the experience of the learning game designing came the recognition and communication language for a cooperative relationship between the content expert, the learning designer, and the digital learner to construct an optimal GLE. For use in conjunction with the gamification alignment table, a **gamification alignment model** was developed to assist learning designers and teachers to match the types of games to deliver different gamified learning experiences. This aligns to the thinking skill levels of Bloom's (1956) taxonomy of learning. The gamification alignment model, populated with concepts and pedagogical verbs, can be readily used by educators and learning designers in planning and designing GLEs.

6.4.4 Methodology

A **generalised conversational framework** to inform design and evaluation of gamified learning experiences, was adapted and developed for this research and future design and evaluation of gamified learning resources. This GLE framework, shown in Figure 21, illustrates the cyclical design and evaluation process wrapped around, and tracking, Laurillard's conversational framework (refer Section 3.3.7, Generalised theoretical framework). The critical aspect is the dynamic and continuous cycle of design, implement, engage, review, and revise, from both sides of the teaching and learning experience. In the first design iteration, moving clockwise and starting on the teacher side of the model, at the top right, the GLE is conceived and designed by the content expert and implemented when delivered to the student. The student then perceives the content and engages with the GLE, resulting in scaffolded learning and feedback, performance outcomes, and data gathered during the process. Examination of the student's performance and experience with the GLE are then reflected on by the teacher. Successful learning and teaching approaches are identified. Data on students' engagement and performance results in and supports scaffolded revision and redesign of the GLE for the next iteration. Moving into the next and subsequent design iterations, the GLE is extrapolated and replicated, with continuous development of pedagogy for learners.

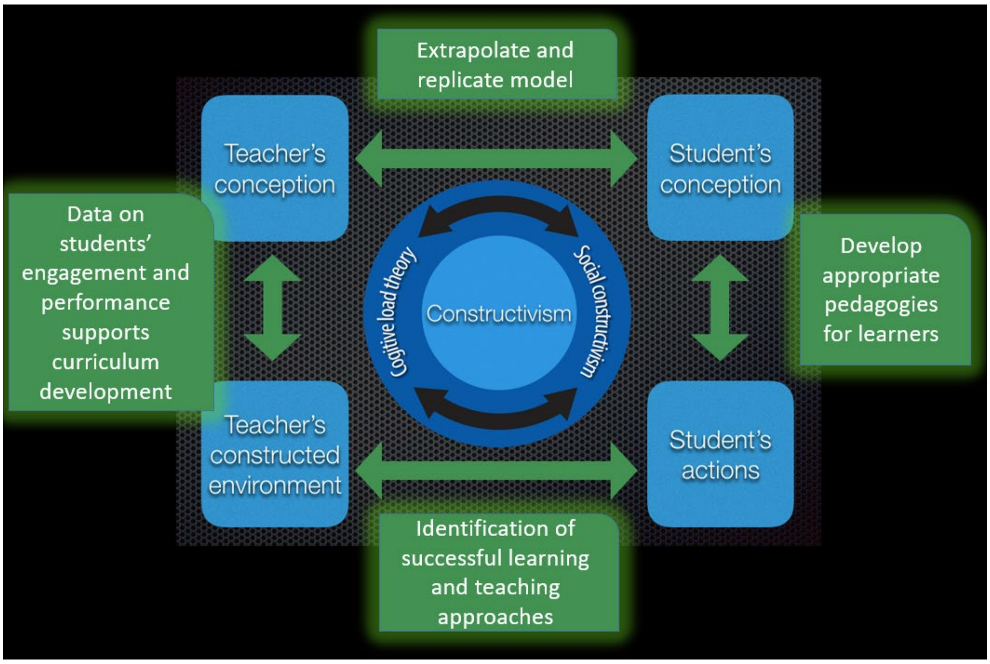


Figure 21 **GLE framework for design and evaluation**

To date, research has considered and reported parts of this model, but not the entirety. Where previous studies collected data on learners' enjoyment of educational games (Fu et al., 2009; Grund & Meier, 2016), they still endorsed the view that the inclusion of the elements of games designed for entertainment would produce the environment for flow (Csikszentmihalyi, 1990). Grund and Meier (2016) further suggested that, through achieving a balance of challenge and difficulty, the learner would be motivated to achieve the learning objectives. Radoff (2011) recommended the inclusion of a narrative to engage learners in a GLE. Klopfer et al. (2012) focused on the accumulation of points and progression through game levels to find where the learner collected information and accumulated knowledge. For game-based assessment, Eseryel et al. (2012) encouraged the inclusion of complex problem-solving skills, and the observation of interactions between players and the educational game to inform the learning game design. Encompassing all of these proposals, Kapp (2016) stressed the importance of discovering what features lead to learning in games. The GLE framework for design and evaluation, as developed and presented earlier in this thesis, can direct and assist learning designers and teachers in all these stages.

6.4.5 Learning design

Even given the guidance provided by all these previous researchers and the inclusion of the abovementioned tools and suggestions, it is clear that gamification is not a panacea or universal remedy as the literature has pointed towards. There is value is identifying key elements of student engagement with content and expressions of learning in learning games and work to enhance those in other learning activities. Commonalities that accentuate student engagement as tabled in Section 3.2.2, Gamification Alignment Table, are for example: plot driven narrative, personalisation, level of challenge, and immediate feedback. Bell (2016, Slide 4) refers to this holistic process as follows:

> "Gameful Design" attempts to convey that it is the cognitive science and behavioral psychology behind games, not the games themselves that we should focus on. It [gameful design] has the most potential to enhance Student Intrinsic Motivation.

Following the GLE framework for design and evaluation (Figure 21) presented in this thesis, future gamefully designed curriculum will be able to use a cycle of learning something new with scaffolds, using and applying that knowledge independently with immediate reward for performance, building on "recently assimilated skills" (Bell, 2016, Slide 23), and taking on increasing challenges where higher order thinking skills of analysing, evaluating, and creating are evoked.

Advances in technology have enabled more sophisticated GLEs to be designed and created by education practitioners without reference to costly external specialists. This research has produced a GLE that is most effective for increasing learners' self-efficacy and learning experience in TVM using a validated instructional design model, and gathered experiential and performance learner data prior, during, and after the experiment. However, beyond learning design for threshold concepts in accounting and finance, as the broadening participation in higher education continues within Australia and other countries, the issues of diverse student readiness to study at university, first-year retention, persistence, engagement with learning, and rewarding student experiences are of mounting importance. Increased international student mobility to take on education with a first language other than English also creates a need for increased autonomy in learning that is not governed solely by classroom activities and teacher-centred learning designs.

Gamified learning may assist with this widening of participation, to create confident learners from marginalised backgrounds, who will ultimately develop the ability to succeed at lifelong learning, and not just university learning. This research created and refined replicable tools for mapping and creating technical threshold concepts pedagogical resources, specifically in the accounting and finance. It will readily translate further into other business threshold concepts, and those of other disciplines, with the potential to move into broader andragogy and heutagogy: financial advisors, banks, and other accounting and finance professionals, for client awareness and education. Businesses and other institutions that rely on professional and situated learning in-house may be able to take advantage of and benefit from modularised gamified learning opportunities. Such professions and business with employees who have not been engaged in professional development and have fallen behind in computer and software skills and the intricacies of their vocation may find the gamified approach to learning something that might recondition these elements of the workforce when they have lost confidence in their ability to cope and learn new things.

Looking beyond the immediate opportunities for dissemination, to potential impacts in broader and new research directions, there is a contribution to be made in moving the focus from an examination of GLE for the learner to that of the educators and ways in which the educators might modify their teaching behaviour to further encourage self-efficacy. The layers of inquiry could be:

(1) design and facilitation of learning by the teacher, the course and curriculum designers, learning designers, and educational technologists, and (2) the development of their technological, pedagogical, and content knowledge in a group design environment as advocated by Koehler and Mishra (2005). From there the capacity to influence the organisation's curriculum policy, the national higher education sector, and the international higher education sector become possible.

6.5 Limitations

6.5.1 Physical

The game was published as a SCORM file into the university's learning management system and provided some non-invigilated time on task data for inferential discussion, but pathways and repeats (part or full), game score accumulation and bonuses found (and therefore a leader board), were beyond the scope of the budget for this research. Repeats, improvement, and perceived in-game experience; that is, how the learners responded to feedback and scaffolds embedded in the GLE, are all metrics in need of further investigation.

6.5.2 Sample

Experimental design in education using a treatment and a control group requires that participants are drawn from a total population. Yet, so as not to disadvantage one group over the other, the experiment must be conducted outside of the usual curriculum activities so that is it does not form part of their formal assessment. Participants were required to volunteer their time. This invariably leads to small sample sizes and self-selection bias. The final sample was collected over an 11-month period and although small, was found to meet the assumptions for statistical testing and analysis. The voluntary nature of participation would also likely have produced a degree of self-selection bias, where the participants were already engaged and interested in the content and prepared to do the extra work to further their studies. "[H]igh achieving students always access and pursue extra tools like online quizzes … but the struggling students are the more difficult to engage in extra optional support" (Hancock, personal communication, 2 September, 2019). While it was determined that the participants in this research were a representative sample (as discussed in Section 4.4: Data collection and sample) of the total population of accounting and finance students, a whole of cohort data sample would have obviated any concern for this limitation. This could be achieved by inserting the GLE, and its complementary assessment and survey questions, into the learning resources of units where the threshold concept is taught. Participation would still be voluntary, but visibility and uptake could be increased.

6.5.3 Textual

Purposive sampling for the qualitative analysis limited the capacity for thematic analysis. For future research, a larger number of representative sampling transcribed interview data sets would address this limitation. With the additional of more open-ended questions, interviewees would not only be encouraged to reflect on their learning experience with the GLE, but also to put forward suggestions and ideas for future iterations of the GLE. A larger data set would allow for the extraction of themes in engagement with learning and design, and assist future learning designers.

6.5.4 External validation

The nature of the GLE for accounting and finance also meant that the sample was ultimately limited to a homogenous discipline group of learners and therefore the generalisability of how the results can be applicable to another setting may be hampered. Technical threshold concepts, particularly applied concepts where learning can be assessed within the GLE in a digital binary form, will easily translate. This would also hold true for groups of technical threshold concepts that build on each other and where learners can move through the game to more advanced levels. Similarly, for technical threshold concepts from other areas, broadly the STEM disciplines and health sciences, varying the story to match the language of the discipline will enable application. Threshold concepts in disciplines such as law and the liberal arts would prove more challenging with the current model because they require more subjective thinking skills and analysis.

However, the current design model for the GLE Framework design and evaluation will be useful for other key technical threshold concepts in accounting and finance. Specifically, TVM discounting and annuities, and accrual accounting concepts would readily translate into GLEs that could be included in the pedagogical tool box of educators.

6.6 Summary

This chapter discussed the reported demographics and learning preferences of research participants and considered the influence of these on the learning experience and outcome results. Multivariate ANOVA interpretation then examined the correlations between learning experience and outcome results and made inferences about learner engagement, learning success, and self-efficacy. This multivariate ANOVA method and GLE design framework were used to evaluate the imposition of the GLE experiment as a pedagogical resource in AFTTC, and to compare and contrast it against existing pedagogical resources. A new subset survey – eLearningGameFlow – containing only items that were learner centred was developed and tested using the multivariate ANOVA method. Contributions and limitations of the research were discussed. The next and final chapter, Chapter 6: Conclusion, concludes this thesis with a summary of the outcomes and contributions of the research, the revised model, an acknowledgment of the limitations and inhibitors, and indications for directions of future research.

Chapter 7 – Conclusion

7.1 Introduction

This final chapter concludes the thesis with a summary of the outcomes and the contributions of the research, the revised model, an acknowledgment of the limitations and inhibitors, and indications for directions of future research.

7.2 The overall objective

Recall from Section 2.4: Learning design for student engagement, that the most common challenge for a gamified learning experience (GLE) is the test of being pedagogically sound (Arnab et al, 2013). The big question being, “Can learning happen in games?” The GLE not only has to provide a different learning experience but also a better or at least an equal learning experience to traditional methods, to justify the investment in time and money. In an effort to contribute to the literature on the gamification of the curriculum, this research linked the pedagogy of the GLE to learning design by seeking to identify what learning conditions support gamification, the gamification features that lead to learning, and how can they be integrated to ensure learning outcomes are met.

Within the generalised conversational framework, this research used experimental mixed methods sequential strategy with participants allocated to either the control or treatment group. Multivariate analysis was used to investigate the participants’ construction of knowledge through the learning experience, assessment of learning, survey. Text mining software was used to analyse follow up interviews.

7.3 Expected outcomes

The research was designed to evaluate the effectiveness of a gamified curriculum pedagogy for delivery of a technical threshold concept, time value of money (TVM), a key component of accounting and finance education. The expected outcomes were:

- To provide data on students' engagement and performance under each condition for use in supporting accounting and finance curriculum development.

- To identify innovative and successful teaching and learning approaches for the technical components in the accounting and finance curricula.

- Laying the foundations for expansion of the research, through replication and extrapolation of the model within the interdisciplinary common courses of business, and potentially across other disciplines in higher education.

7.4 Key conclusions and revised model

The application of the treatment GLE only demonstrated a significant relationship between participant self-efficacy with the technical threshold concept of TVM and the GLE, and not between engagement with the content or assessed learning outcomes of the technical threshold concept of TVM and the GLE, however, the data collected has provided insight into the student experience and performance. While a successful hypothesis is rewarding to the researcher, the critical task is revisiting the design model to contemplate other educational resources and overall curriculum design to address the unsuccessful hypotheses. In response to this, in Section 6.4.4, the design model was further developed and described as being an interactive and continuous cycle of design, implement, engage, review, and revise, from both sides of the teaching and learning experience. Interactivity needs to be considered not only at the interface of the learner's physical experience with the GLE, but also the teacher/designer's implementation and conception of how that will play out. Learner interaction with the narrative for investment in the story of the content needs to be considered in the review and reflect stage to understand how the learner interacted with the GLE, then again in the (revise) design stage to match the teacher's conception with the learner's interaction (Eseryel et al., 2012). This considered iterative design process is essential to facilitate active use of the resource (Massoudi et al., 2017).

In a further effort to ascertain any embedded reasons why the hypotheses were unsuccessful, the researcher conducted a more detailed examination of the individual items of the eGameFlow survey used for testing. After removal of 18 items which measured the design of the game, 12 learner focused items persisted to become eLearningGameFlow: a tool for measuring students' learning experience in the game. The use of eLearningGameFlow will potentially allow learning designers to not only do their best creating GLEs which deliver an equal or somewhat apparent approval in learning outcomes and student use and engagement. As a learning testing tool, eLearningGameFlow may assist in identifying and measuring the actual learning points for replication.

7.5 Implications for theory and practice

With nearly every university now having their biggest student cohort online, there has been significant change in the expectations of students for their learning experience. From the relative novelty of the first forays into gamified learning, a more sophisticated interface and immediate response time is now demanded. Belland (2012) acknowledged that the collection of quality data from game-based learning and assessment to facilitate designing appropriate assessment was central to designing learning games and called for measurement of learning during game play. Building on this and using an iterative process of design, evaluate, and reflect, the GLE in this research collected experiential as well as performance outcomes data, and has contributed to the enhancement of learning design of accounting education using a GLE in contrast to the traditional use of tables and derivation of formulas. To assist educators and designers, this research has produced a **gamification alignment table** (Section 3.2.2), the **GLE framework for design and evaluation** (Figure 21), a published example of a self-contained **GLE for a technical threshold concept**, and the **eLearningGameFlow survey** (Table 23).

At Southern Cross University, the GLE created for the experiment has been included as a learning resource in the accounting and finance units, where TVM is a foundation technical threshold concept. The game level containing the learning objectives quiz continues to collect performance data online. The GLE is available as a multi-directional tool for all students to use independently, and to utilise time and again as a reference or refresher. For education designers the GLE itself is a standalone pedagogical resource or can be integrated into the curriculum. The universality of design provides wide accessibility and the TVM story is generic enough to span multiple disciplines. From a commercial perspective, interest has been shown by accounting and finance textbook publishers to include the stand-alone GLE as an additional resource in their eEnhanced texts.

With the finding of a significant difference in H3, self-efficacy, it is timely to consider where, and for what type of learner is self-efficacy most important. This research has revealed the opportunities for embedding GLEs into MOOCs and pathway programs that take learners who are less confident in their ability to succeed with learning and prepare them for higher or even university learning.

7.5.1 Inhibitors to change

As noted in Appendix 1: Section 8.8, Key lessons learned, the principal researcher, filled the roles of teacher, content expert, instructional designer, and educational technology designer. This required a wide lens, an innovative outlook, and an awareness of and openness to digital technologies and pedagogies. Not only is the investment in the resources of time and funds extensive, embedding GLE into curriculum requires acceptance and ability of educators (Barcan, 2016). Watty et al. (2016) argue it is the resistance of accounting educators to embrace educational technologies, not the technologies themselves that is the greatest challenge for curriculum designers, stating “academics need to become innovators rather than inhibitors” (p. 1). Marklund and Taylor (2016) also recognised the impact on educators’ time and resources, and the constraints of technology capacity, warning that ad hoc inclusion of games into curriculum, not a gamified curriculum, misses out on the total integrated learning opportunity of games.

Comparing the process of education to practise of business, if a business' value statement is a declaration of priorities and core beliefs, that guides the actions of employees and customer relationships, then the value statement of education, in particular relating to threshold concepts, would be to declare the importance of foundational learning and seek to develop pedagogical resources that benefit learning. Perhaps there is a positive value statement to be made regarding costs versus outcomes in the development of gamified learning experiences. While the physical costs may be identifiable and measurable, what is the time value of learning? Measuring the value of learning over time may well be impossible, but, as educators, surely we would agree that it would be positive, and the initial costs in research and development of the gamified learning experiences justified.

7.5.2 Action

The findings of this research indicate that a GLE has the capacity to embed the confidence for students' learning, and improve the learning experience, of technical threshold concepts, and this can be used as a basis for more advanced concepts. Following on from the time intensive creation of the initial GLE, and using the replicable model and lessons learned, expansion of the gamified curriculum to more complex aspects of TVM are planned, to meet the learning needs of students using critical thinking in the digital space.

> Maybe a follow up game. If there was like a mini game like a redo. "Do you want to try it again and see how you're learning?" Like how much do you remember? Without, or even if you did the same game without, any of the tips and hints. Maybe have the competition on the expert level. (Participant EL)

Subsequent GLEs will continue to be guided by the question, "How do we make the games where the learning can happen?"

7.6 Future research

Looking deeper into the learning outcome findings, where there was no significant difference between the groups, suggests that the “troublesome” in the troublesome technical threshold concept of TVM that learners have difficulty surmounting, might not be the mathematical formula use problems, but the application of theory questions. Embedding the TVM GLE into the pedagogical resources of the curricula for accounting and finance units and examining performance data collected over a number of student cohorts as part of their unit requirements, may provide more insight into where design attention should be focussed. In the future it would be useful to expand to another discipline or another technical threshold concept to more broadly gather data from larger more diverse groups and describe how these different dimension variables influence the results. The potential adoption of the GLE and the eLearningGameFlow survey by other institutions, this would also allow for additional analysis. With the diversity represented in various higher education student cohorts, there may also be the opportunity to broaden the consideration to different personas of students and determine their responses to the GLE.

It would be of interest to re-visit the students surveyed and interviewed, after a few years, to ascertain any longer-term benefits of using the GLE, in terms of learning experience and knowledge retention. Future research into the persistence of participants’ self-efficacy and retention of learning, via longitudinal studies would also prove beneficial for guiding subsequent design iterations. Also, in a world of survey saturated students, the application of the revised 12-item eLearningGameFlow offers a quick and effective measure of *experience of student learning* within any GLE.

7.7 Summary

Just because we can, does not mean we should. Without thoughtful, well rounded consideration to all components of learning, learners, and desired learning outcomes, a gamified learning experience is reduced to just gamified experience. The investigation of interactive reflective prompts or scaffolds, combined with insight into the participant's rationale and theoretical underpinning for choices, demonstrates that not one size fits all for learning. This was reflected in the created GLE for this research as an example of the new culture of learning (Thomas & Seely Brown, 2011). Attendance to the learning design cycle of a GLE within Laurillard's (2002) Conversational Framework where the constructed learning environment is designed, engaged with, reflected upon, and revised, is imperative to facilitate the flow of knowledge construction and learning experience.

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> What's happening with your PhD? I've got the team together. Are you in? (Dr Jacqueline Christensen, 2016)

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Appendices

Appendix 1 Creating the Gamified Learning Experience for the Time Value of Money

8.1 Introduction

This chapter will review the researcher's actual development of, and reflection on the experience of developing, the experiment treatment gamified learning experience for the time value of money; the checks and balances employed to ensure the reliability, rigour, trustworthiness, and credibility of the treatment; and the design considerations to facilitate replication and generalisability. In describing and reflecting upon the process of developing the GLE, links to the gamification alignment model are considered and elucidated.

8.2 Development of the time value of money gamified learning experience

Soflano et al. (2015, p. 107) proposed that "role-play games … ha[ve] the potential to deliver any type of knowledge and ha[ve] more elements that can be used to deliver learning materials." Soflano et al.'s (2015) study used two modes for the same e-learning game. The first, a non-adaptive mode treated all learners the same. The second, an adaptive mode, identified learner characteristics during the e-learning game via their choices in set up (e.g., personalisation of an avatar, environmental control for movement within the e-learning game, how they choose to have the information displayed, and further challenges).

Due to the resources available (see Sections 8.5.1 and 8.5.2), the development of the GLE for this research reflected a modified adaptive mode, incorporating some individualisation choices and allowing for personalised learning paths. By blending the learning material into the plot driven narrative of the game's story the learner is part of the challenge of the game. In the role play game adaptive mode, the learner is central to the plot driven narrative from the first engagement and this provides the ideal launch point "to teach the learning materials without losing the ‘fun’, that is, to keep learners motivated and engaged to learn” (Soflano et al., 2015, p. 107).

The development of the GLE for the accounting and finance technical threshold concept time value of money (TVM) used the architecture of a role play game and traced the path and development of knowledge required to make optimal financial decisions, using the following components:

- TVM learning objectives
- definition and notations
- questions to be tested within the GLE, and
- identification of variables.

All of these follow the traditional pedagogical components, although the development of the GLE adds:

- building the story – the plot driven narrative
- episodes – iterative learning stages - to move through future value (FV), reflection, and then present value (PV), and reflection, and
- opportunity to repeat multiple times.

8.2.1 Learning outcomes

Business finance texts (e,g., Berk et al., 2014; Parrino et al., 2016) universally outline the learning outcomes for the study of TVM to be, at the completion of this unit the student will be able to:

1. Explain what the time value of money is and why it is important in the finance.
2. Explain the concept of future value, including the meaning of the terms *principle*, *simple interest*, and *compound interest*, and use the future value formula to make business decisions.

3. Explain the concept of present value, how it relates to future value, and the use of the present value formula to make business decisions.

4. Discuss why the concept of compounding is not just restricted to money, and use the future value formula to calculate growth rates.

These learning outcomes are all situated in the lower order thinking skill of comprehension, with reference to Bloom's taxonomy (1956). The purpose of the GLE for TVM is to allow students to demonstrate higher order thinking skills by solving problems and making decisions. These are features of the learning game that can improve on the teaching and learning of the threshold concept. The lower order thinking skills are still included in the content of the game, and the students have the opportunity to demonstrate their learning in the game-based assessment in the final level of the game.

8.2.2 Definition and notations

TVM is a threshold concept that reflects the idea that people derive greater benefit by consuming now rather than later. In order to persuade them to consume later, there must be some compensation; that is, the value of the same number of units must be greater in the future than it is today. This requires calculations over time periods to arrive at two different views of TVM; *future value* and *present value*.

The future value (FV) is what a current asset or investment will be worth at a specified date in the future after growing at an assumed rate of interest over one or more time periods. The initial amount, the present value (PV) is converted into its FV through *compounding*. The formula to calculate FV is:

$$FV_n = PV \times (1 + i)^n$$

where:

FV_n = future value of investment at the end of period *n*

PV = original principal (P_0); also called the present value

i = the rate of interest per period

> (Note: This is the term used to describe the cost of borrowing money or the return to the owner of the funds which are invested or lent out. It is usually expressed as a percent per annum of the amount of money borrowed, lent or invested. https://www.rba.gov.au/glossary/)

n = the number of periods; a period being a year, a month, a day, or some other unit of time

$(1 + i)^n$ = the future value factor

Conversely present value (PV) is the estimated current value of a future amount to be received or paid out, discounted at a given interest rate. The formula to calculate PV is:

$$PV = FV_n/(1 + i)^n$$

where:

PV = the value today ($t = 0$) of a cash flow

FV_n = future value at the end of period n

i = the discount rate; the interest rate per period

n = the number of periods; a period being a year, a month, a day, or some other unit of time

$1/(1 + i)^n$ = the discount factor

8.3 The design map

The design map in Figure 22 is a simple example of how the learning designer may start mapping the process for the GLE of the accounting and finance technical threshold concept, TVM. This paper prototype representation of how the learner will experience the learning pathway through the GLE, places the learner as the character at the top/entrance to the GLE and presenting them with a choice (a logic gate) of two options. Each of which lead to other gates with options. The GLE with a plot-driven narrative provokes critical thinking about alternate outcomes of choosing to either save for the future or spend now, because there are alternatives (Item A or Item B) as a conclusion, or a moral to the story (Cost or Benefit).

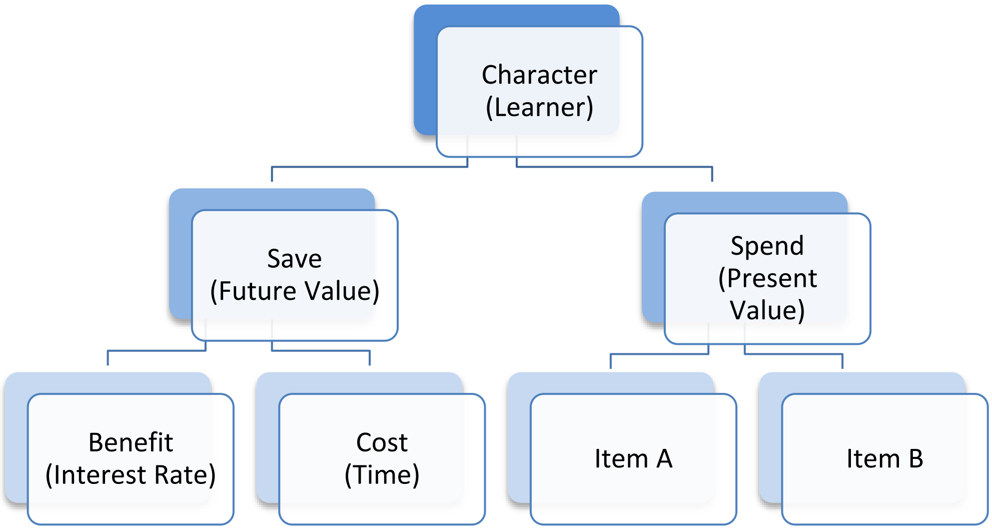

Figure 22 **Simple design map from paper prototyping exercise**

Upon starting the actual designing of the GLE, and with reference to the constructive nature of the content and the sequence in the control group video, another level was included in the GLE Design Map. This is the first or top level under the character (Figure 23) – Simple interest/Compound interest. This level scaffolds the first terminology and concept that the learner must understand in order to successfully progress through the TVM GLE. From here they have the tools to move to the next level, future value – building, or deriving, the TVM formula – and then the subsequent level, present value – manipulating the TVM formula and recognising the properties and use of the discount factor.

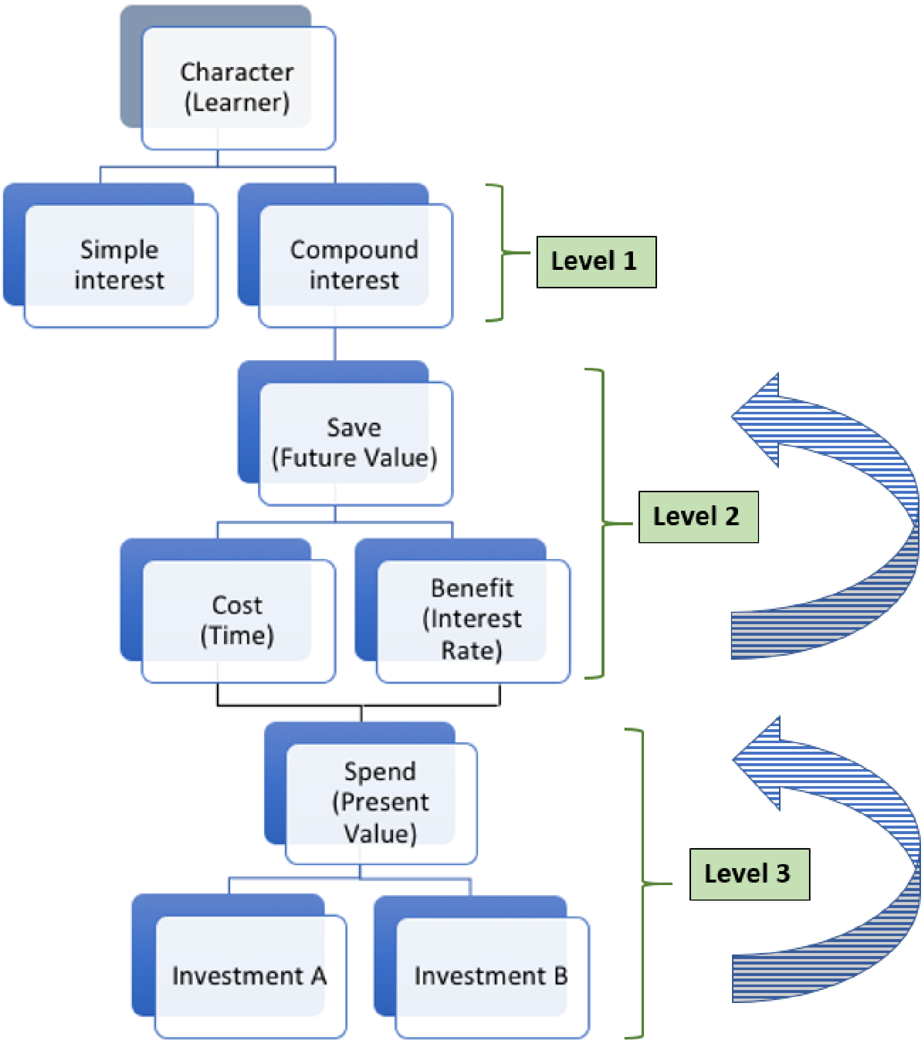

Figure 23 **Design map: Episodic plot driven narrative contained within each level, with multiple repeats of the levels available, as shown by the looping arrows**

8.4 Aligning the literature

8.4.1 Accounting

Consideration was given to match the characteristics of the threshold concepts to the GLE. Meyer and Land (2003) determined five characteristics of threshold concepts. They are transformative, irreversible, integrative, represent a boundary and are troublesome. A GLE offers a pedagogic approach to support learners' transitions through these troublesome barriers to engagement and learning, by employing content and technique with social practise. These were matched to a GLE (Table 27), and the last column added to describe how these characteristics were operationalised in the TVM GLE.

Table 27 Characteristics of threshold concepts matched to the GLE for TVM (extended from Meyer & Land, 2003)

Characteristic	Threshold concept	GLE	GLE for TVM
Transformative	• requiring a significant shift in thinking or world view	• immersion in the GLE as a character or avatar with different scripts, backgrounds, and sets of attributes	• choice of 2 avatars to represent learner
Irreversible	• cannot be unlearned (they are part of semantic memory)	• artefacts, improvements, and attributes are carried through to future missions	• information is presented via artefacts and can be revisited
Integrative	• merged seamlessly into the existing schema	• progression through the GLE is cumulative	• learners collect more information by moving through the story
Represent a boundary	• movement into a new level of understanding	• progression through the worlds or scenes of the GLE with ever increasing levels of complexity, understanding, and skill required	• each level builds on the previous learning

Characteristic	Threshold concept	GLE	GLE for TVM
Troublesome	• counter-intuitive, incoherent to current way of thinking and knowing	• progression requires alternate approaches to a task to achieve a favourable outcome	• learner is asked to make choices and consider outcomes

Cognitive load theory

As per Mostyn's (2012) application of cognitive load theory to introductory accounting, the design of the GLE controlled the complexity of content and offered supplementary material using the learner's progress through the levels of the game. This is the chunking principle (Miller, 1956) at work; separating and sequencing interactive elements of a topic.

Authentic learning

Meaning is created through exploring in real-world situations that are relevant to the learner. Of the authentic activities that lead to authentic learning, identified by Herrington and Oliver (2000), in particular the GLE incorporated:

- Real-world relevant activities matched to scenarios encountered by learners: buying a car, purchasing coffee, saving for graduation.
- Activities that spanned whole of concept, with formative development scenarios building the TVM formula towards a final solution as an assessment item.
- Opportunities to reflect on choices and consequences, by considering implications of alternate actions: The pop-up prompt in Figure 24 – "Are you sure?" – asks the learner to reconsider the choice they made by clicking on waiting until the end of the year to receive money. By clicking on either the alternative artefact – the money bag – or the yellow prompt "Are you sure?", they are directed to additional information about the time value of money.

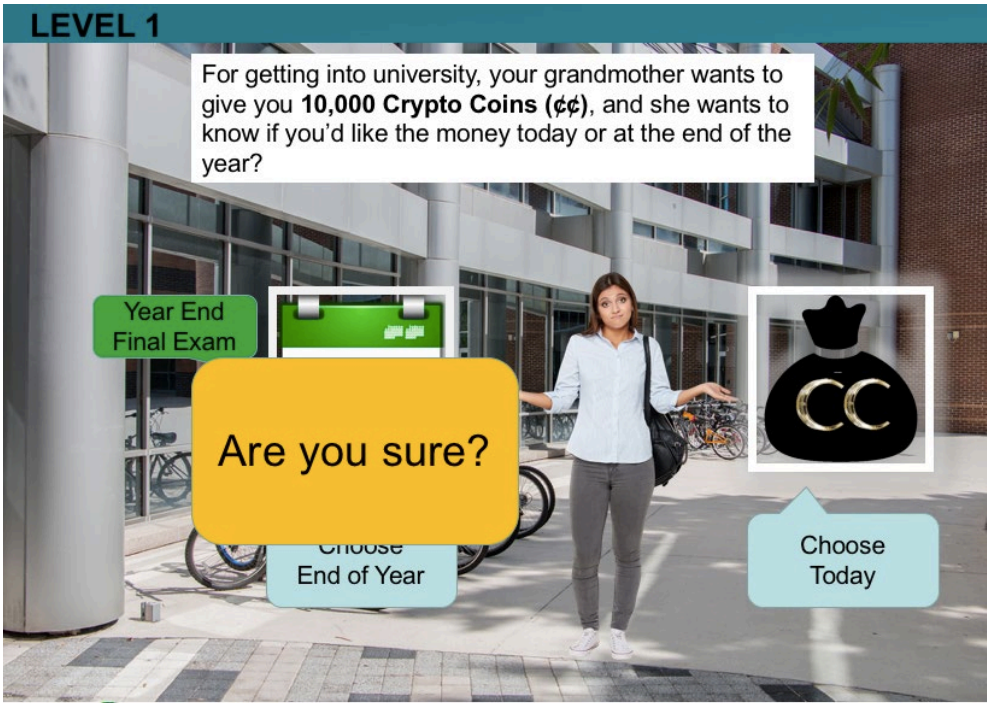

Figure 24 Opportunity to reflect on the choice of "money today or at the end of the year"

8.4.2 Incorporating the pedagogy

Engagement

Recall Section 2.4.1.1 Engagement, specifically engagement as a learner centred concept (Appleton et al., 2008), talked about learners as if they were all "Susans", (Biggs & Tang, 2007) who were deep learners and already engaged with learning, as distinct from "Roberts", who were less engaged and surface learners. This latter group would find the GLE most useful for learning as it encourages cognitive engagement, behavioural engagement, and even emotional engagement (Appleton et al, 2008) after rewarding experiences of success with learning. The rewarding experiences are built into the GLE in the form of points for level completion and also bonus points for additional artefacts uncovered. These are reinforced with positive emotional images as indicators of success (Figure 25).

Figure 25 **Bonus Points awarded and positive emotional image**

Motivation and self-directed learning

The GLE combined Ryan and Deci's (2000) self-determination theory's intrinsic and extrinsic motivations of competence, autonomy, and achievement, respectively. This created a learning environment were the learner was immersed in the experience from the moment they entered the GLE and chose their avatar (Figure 26). They were then propelled forward through the story as the main character, learning along the way. The game world university was generically named Southern Star University, to avoid affiliation and allow for future repurposing.

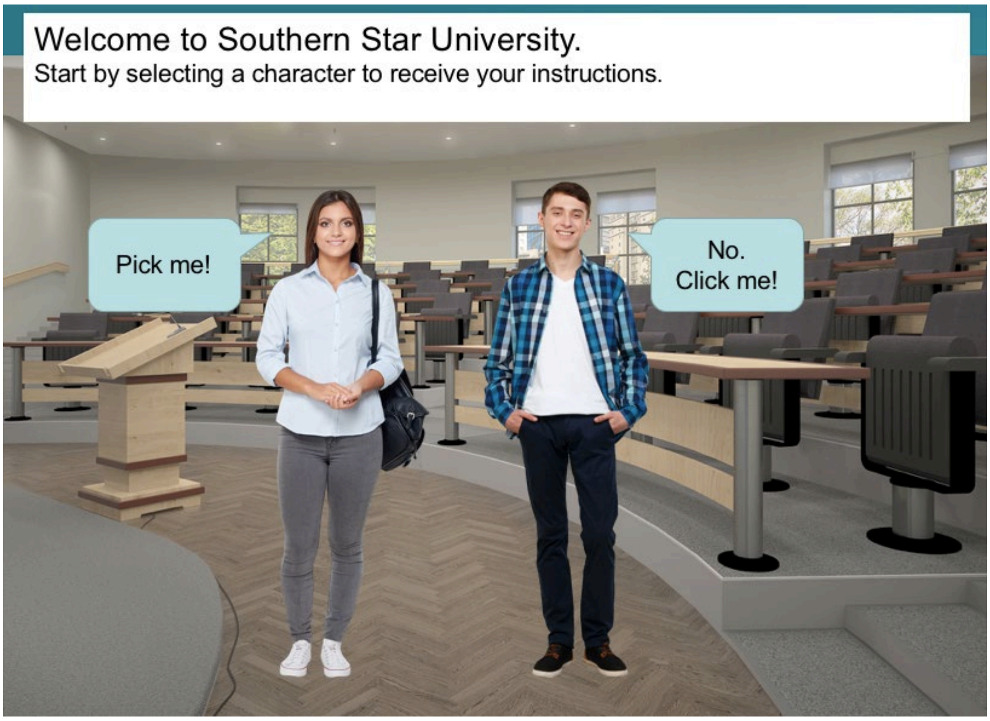

Figure 26 **First scene: Avatar choice**

Inductive learning

Rather than state the TVM formula at the beginning and show examples of it, the GLE steps the learner through the illustrative levels of contextual scenarios and derives the formula from the emergent pattern of the examples (Figure 27). The full formula and the discount factor were built over the 3 levels of the game to this final full version, as opposed to the text book example and formula methods of teaching where it is given up front.

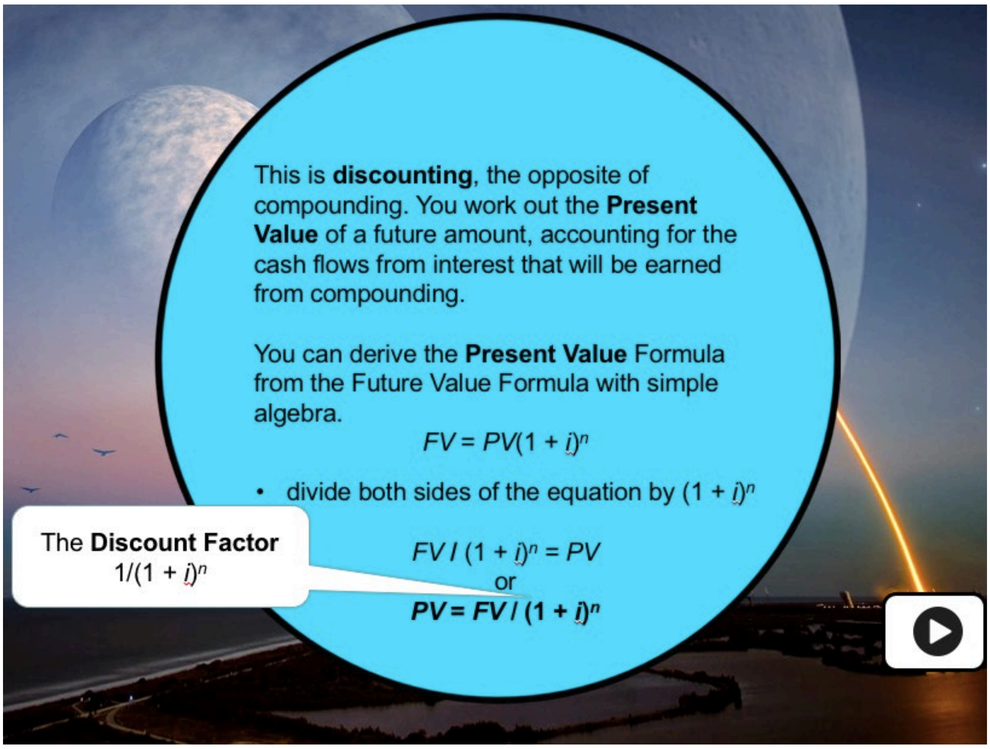

Figure 27 Level 3: Derivation of the full TMV formula

Personalised learning path

The GLE allows for a personalised learning path (Ding et al., 2017) via the facility to revisit and repeat clues, calculations, and whole levels. Hard scaffolds (Chen & Law, 2016) of fixed information and question prompts are embedded into the GLE, introducing more complex tasks as the learner proactively seeks out game artefacts (Figure 28).

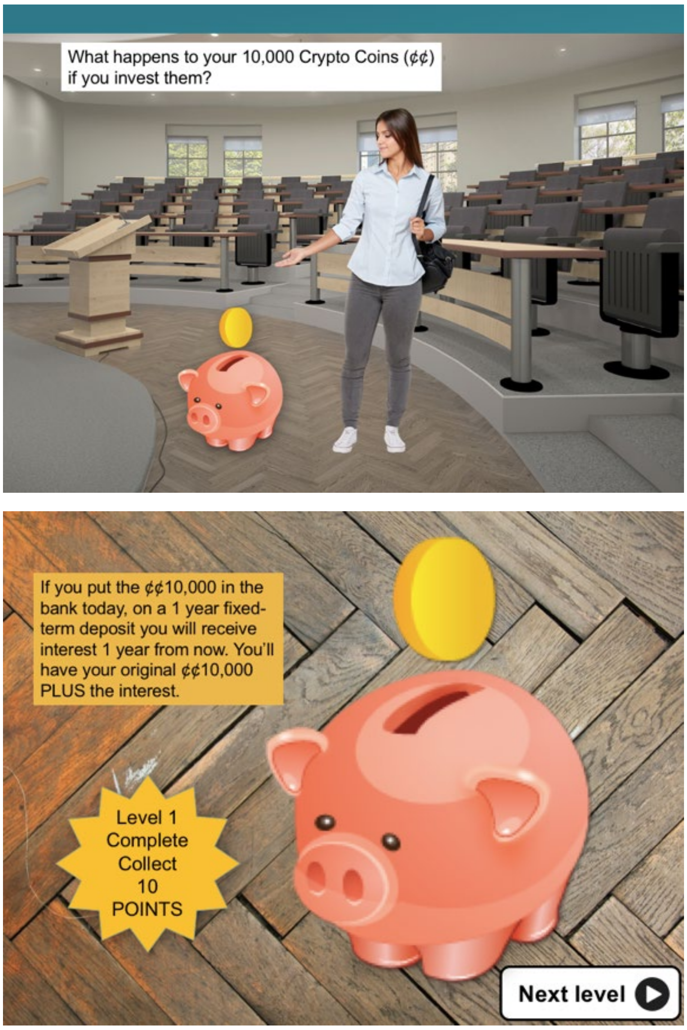

Figure 28 From the question prompt, clicking on the piggy bank artefact, the hard scaffold fixed information emerges

8.4.3 Learning design

Throughout the game development phase, there was constant attention paid to coupling the game design, learning principles, student engagement, and learning outcomes, while still making the game itself function like a game.

Constructivism

To support the learner's constructivist developmental processes the GLE uses built in feedback mechanisms. Feedback is the consequence of the active learning choice a learner takes relative to the intended goal. The TVM GLE requires the learner to interface with the digital platform via a personal device anywhere and anytime. It is self-paced and provides immediate feedback according to the pathways embedded in the design of the GLE's program (Figure 29).

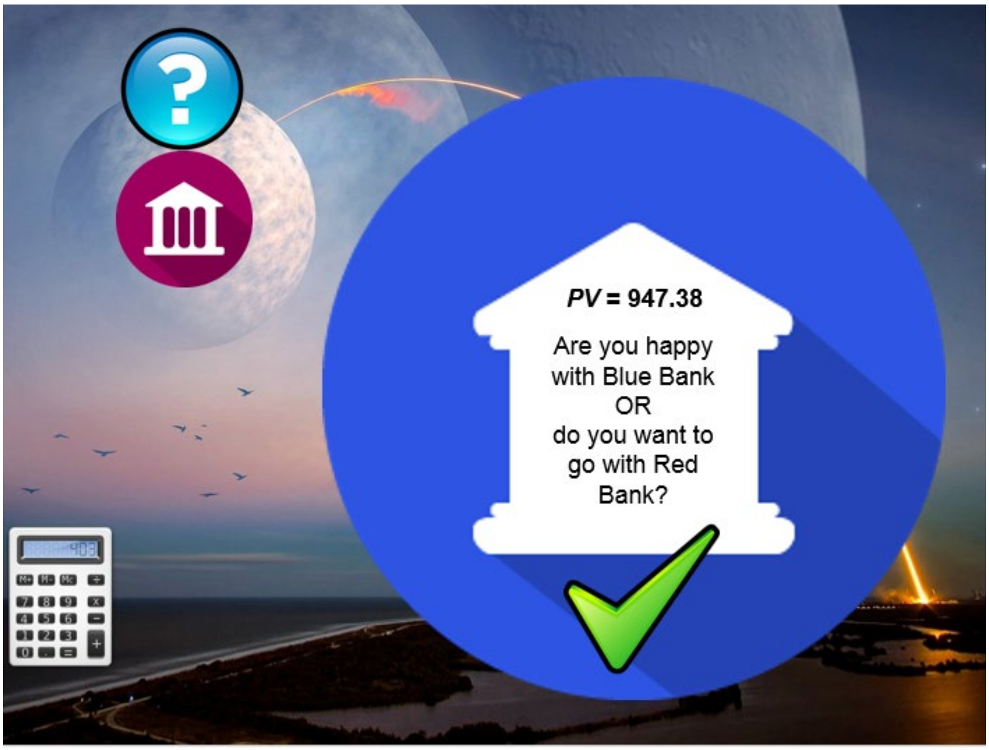

Figure 29 **Feedback provided after learner chooses Blue Bank**

Note. This choice calculates the *PV* based on the interest rate offered: *PV* = 947.38. The learner is then immediately challenged to consider sticking with this choice or doing further investigation.

Constructive alignment

In the design of the GLE, a targeted approach of constructive alignment (Biggs, 2003) was used, aligning learning outcomes with learning activities, measured by assessment and instant feedback to allow opportunities for learners to construct meaning. Figures 30 and 31 show examples of the feedback provided in the assessment level of the GLE.

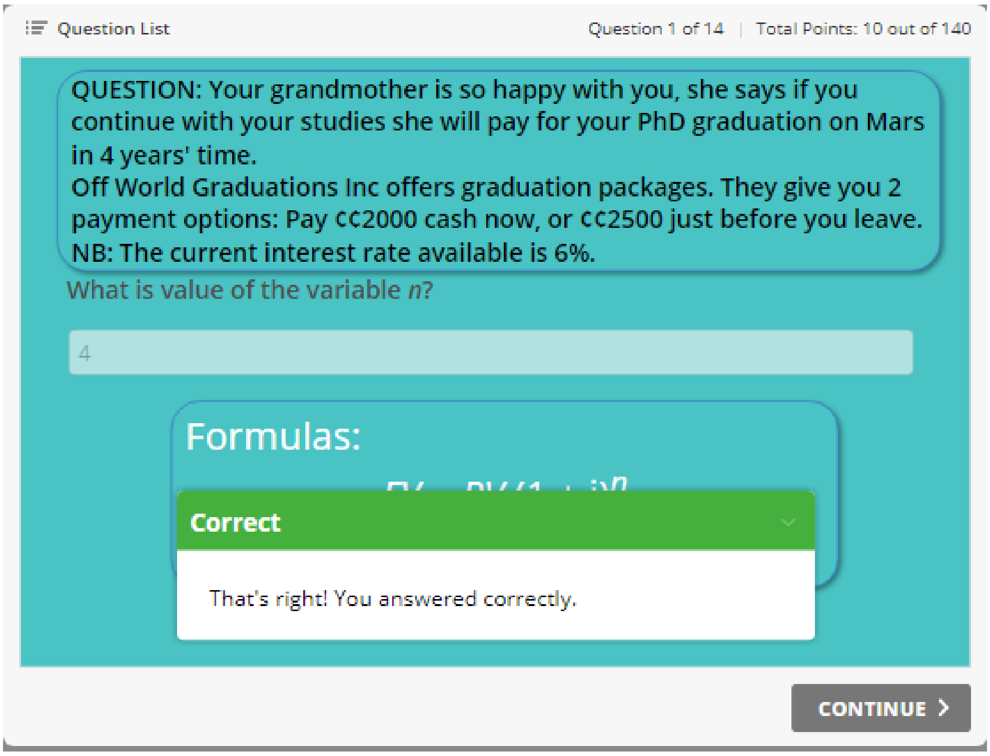

Figure 30 **Feedback for a correct answer**

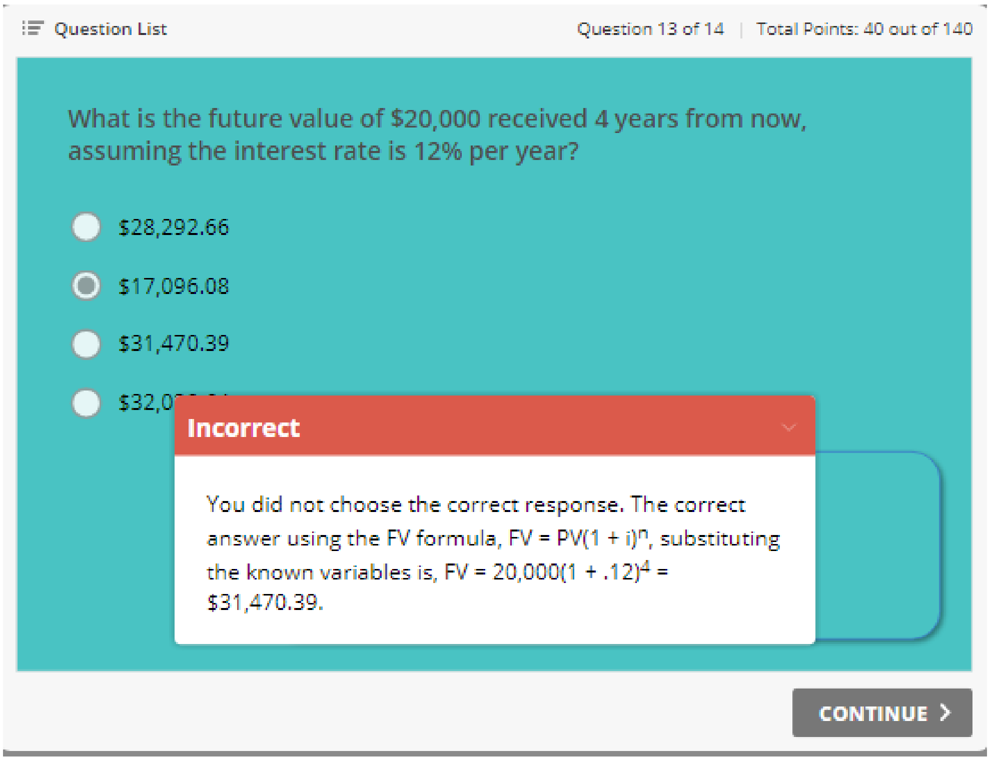

Figure 31 **Formative feedback for an incorrect answer**

Digital learning environment

The digital learning environment has afforded the delivery of the GLE. The teaching role is to guide the learner through the use of hard scaffolds (e.g., clues in the game as shown in Figure 32) discovered during the learning experience, not interrupting the learner's exploration (Bellotti et al., 2012; Thomas & Seely Brown, 2011).

Figure 32 **Hard scaffold active object "Clue" example**

Formative assessment

Recall the discussion in Section 2.5.3 regarding the effectiveness of formative assessment. In the design of the GLE, the e-moderating learning levels of Salmon's (2004) model (reproduced here in Figure 33) were deployed.

1. access and motivation: welcoming and encouraging – using the welcome screen and avatar choice (Figure 26)
2. online socialisation: familiarising and providing bridges between cultural, social, and learning environments – through the story line
3. information exchange: tutoring and supporting use of learning materials – formulae derived and embedded in GLE (Figure 34) accompanied by voice over
4. knowledge construction: facilitating process – levels building to more advanced concept
5. development: supporting and responding – using hard scaffolds and movement within the GLE to revisit and repeat information and levels

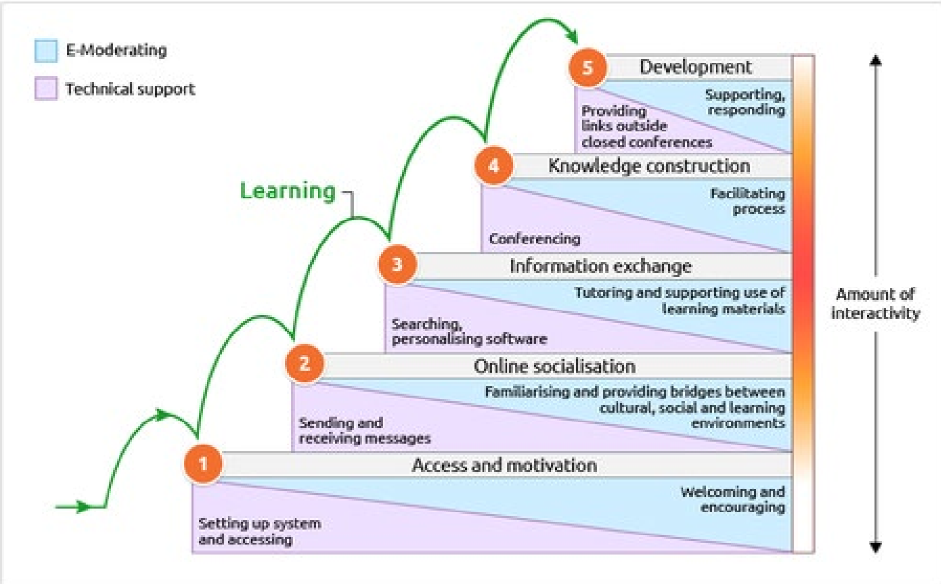

Figure 33 **5-step model of e-moderating (Salmon, 2004)**

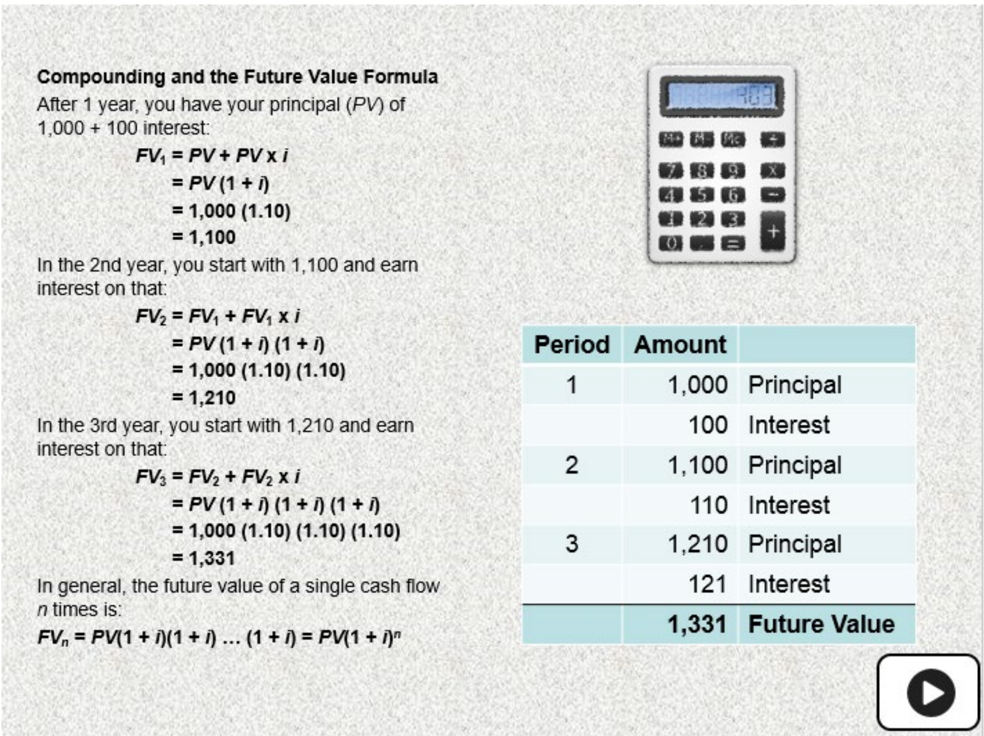

Figure 34 **Tutoring and supporting use of learning materials: Deriving the future value formula on an animated (timed release) slide with voice over**

8.4.4 Gamification

To capture the essence of a game and provide a positive learning outcome, the GLE used structural gamification (defined in Section 2.3.1) by the application of game elements, and content gamification (Section 2.3), with the addition of narrative. The mechanics, objects, and tools that comprised the structure, and defined the actions allowed within the GLE. The learner was still able to exercise autonomy through making choices, investigating alternatives, and collecting artefacts. This was achieved through hyperlinked objects containing hard scaffolds (Figure 32) and *second chance* type pop-up prompts (Figure 24).

To reward success and acknowledge progress, gamification techniques of points and bonuses were included. Although the scope of the software did not allow for an onscreen accumulation of points, learners were able to *find* additional information and points by clicking on objects other than those necessary for the main path through the GLE. For example, in Figure 35, learners could click on the navigational icon in the bottom left of the screen in the top picture, and proceed direct to the end of this level shown in the bottom picture; or the more inquisitive learner could further explore and click on the coffee machine, finding the bonus points in the middle picture, and then proceed to the next level in the bottom picture.

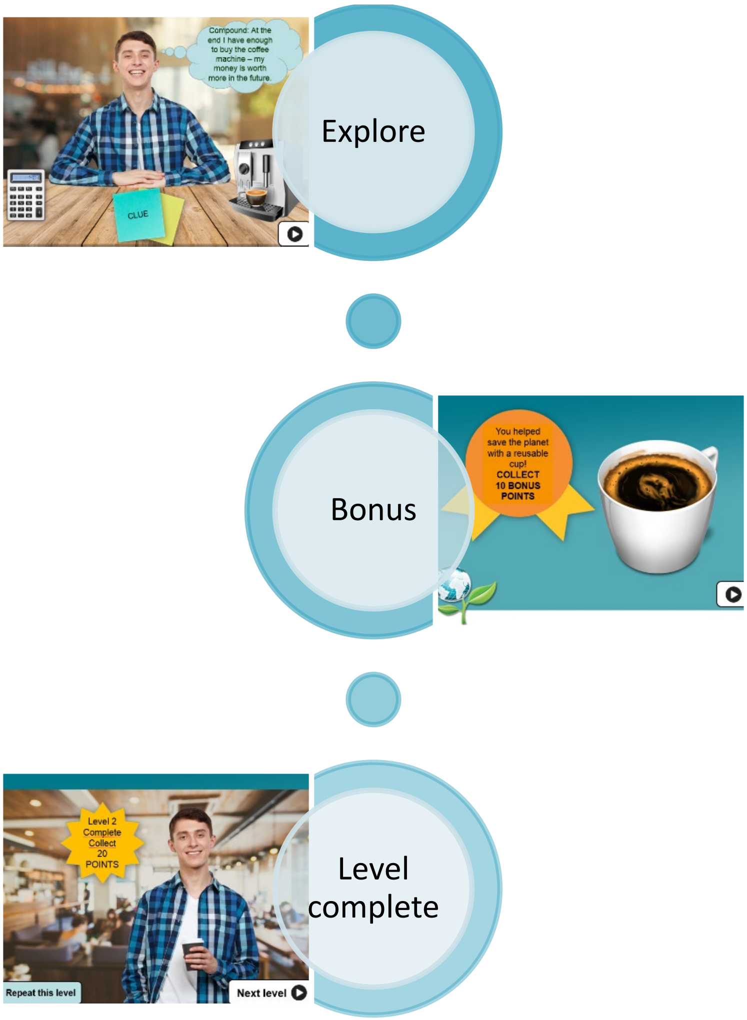

Figure 35 **Finding additional information and points through exploration**

The evolution of the game can therefore be different for different learners, because of the game's mechanics and structures that determine how the learner interacts with the GLE. For example, which decisions and choices the learner takes, in what order, and how many times, determines their path through the GLE.

8.4.5 Learning design

The thinking in the overall learning design was to acknowledge that different game genres will best match the discipline or teaching concept being encapsulated in the GLE. At the same time, it was necessary to consider the characteristics of different learners by using multiple means of representing the content (Gordon et al, 2011). Zwymo's (2003) study supported the use of the Felder Silverman Learning Styles Index to "assess the diversity of learning preferences and to provide both the students and the instructor with an insight into how they approach the learning/teaching process" (p. 224). She added further:

> [I] stress my conclusions around the use of ILS - that the instrument should not be used for making important decisions about students as it deals with preferences that are flexible, not immutable. The intention of the model, as Felder wanted it, has always been to guide the instructors towards a wider range of teaching methods. (Zwymo, personal communication, 27 June, 2019)

For this research, the elements of Felder and Silverman's (1988) learning style model informed the design of the GLE and a comparison of the Index of Learning Styles survey results between the treatment and control groups was used confirm there were no significant differences between the groups with regard to learning preferences.

Also, as discussed in the pedagogy of universal design for learning (Section 2.4.3.1), Rose and Meyer (2002) and Gordon et al. (2011), outlined the design of curriculum based on three guiding principles. The first principle is multiple means of representation, where a broad selection of teaching and learning resources are available simultaneously to appeal to all learner preferences and needs (Gordon et al., 2011). Given that a game like approach to education employs a plot driven narrative storyline to complement the teaching process, the story was also delivered through pictures, words, audio, action, and combinations of these. Not all had to be employed by the learner to proceed through the GLE or even achieve success. The GLE learning design contains trigger questions, episodes, alternate scenes and characters, challenges, and a final objective to demarcate the closure of learning.

Learning within the GLE is scaffolded, learner-driven, repeatable, and time stamped. There are markers of visual demonstration of learning, proficiency, and collection of results, as posited by Jones et al. (2014) (Table 28). The shaded areas of the table: feedback, prompts, achievements, and levels, were included in the GLE. Progress indicators were beyond the capacity of the software used for the game development in this research.

Table 28 Feedback performance indicators in serious games (adapted from Jones et al., 2014)

Feedback Performance Indicator	Gaming example	Game mechanics
Social	*Liking* game progress through a discussion thread.	Feedback buttons and suggestions, and emoticons.
Cognitive	Selection of correct choice from in-game dialogue script.	Prompts, in-game hints, game levels.
Affect	Visual emotion cues and indicators for correct and incorrect actions.	Scoring and achievements.
Motivational	Winning currency or points from completion of game or levels.	Experience points, game levels, lives and virtual currencies to buy game items from online inventory.
Progress	Visual progress of game cache of badges and attributes to highlight learning mastery.	Progress bar, achievements, dashboards.

8.4.6 Traversing the terrain: Reverse rationalisation?

The next section outlines the numerous considerations that wove together to transpose the design map for learning and produce the final GLE.

8.5 Considerations

8.5.1 Software options and investigation

The choice of software platform for delivery of the GLE was constrained by the physical elements of cost, integration, access, and data collection and retrieval limitations. In addition, the experiential aspects of perceived ease of use and actual ease of use for the researcher and learners was paramount. Within these constraints, the GLE needed to deliver an episodic role play game containing a plot driven narrative. It had to have the capacity for multiple repeats in a flexible multi-stage format. It also needed to record and retain learners' results for extraction.

Game researchers have reported that it is the structure and involvement aspects that motivate players, not just the features of the game (Chen & Law, 2016). Although Tuzun et al. (2009) reported higher intrinsic but lower extrinsic motivation for GLE students compared to students in traditional learning environments, Vos et al. (2011) reported that motivation of players drops as designers' motivation and intricacy increases. A more engineered GLE therefore does not necessarily translate into higher engagement and motivation.

8.5.2 Decision

With the concept laid down, the GLE could be operationalised. The first decision was whether to outsource or create. Financial restrictions dictated that the GLE would have to be created by the researcher. The limitations of time and expertise were then considered. Without a coding background for building a game, the researcher had the option of either finding an existing, off-the-shelf game that could be modified to deliver the GLE, or identifying a software that could be used as a platform for the creation of the GLE. The question of external web hosting and/or integration and launch from within the Southern Cross University learning management site, MySCU, ultimately informed this choice, and is discussed in Section 8.7.1, Publishing.

In the search for an existing game, Minecraft for Educators was first considered. Minecraft has been used by educators in K-12, where students model their own buildings, cities, and communities within the Minecraft world to increase their interest in programming. In story mode, Minecraft presents as an episodic point and click adventure role play game, where players build constructions out of generic textured cubes in a 3D procedurally generated world (https://www.gamespot.com/minecraft/). For example, Zorn et al. (2013, p. 7) concluded that it was "an exceptional game with many features that make it an appealing environment for game-based learning. It encourages problem-solving and creativity, and it is immersive and engaging." During the investigation of Minecraft, several game features clarified the parallel markers need in the GLE. These are shown in Figures 36, 37, and 38. In Figure 36, Choosing your appearance, where by selecting an avatar to represent them in the game, the learner is inserted into the game (learning) activity straight away and promoting ownership of the experience. In Figure 37 providing choices as decision gates gives autonomy to own a self-directed learning experience. In Figure 38 increasing levels of difficulty and the chance to repeat levels provide opportunities to achieve a better score. All these components are necessary to engage and propel the learner through the GLE.

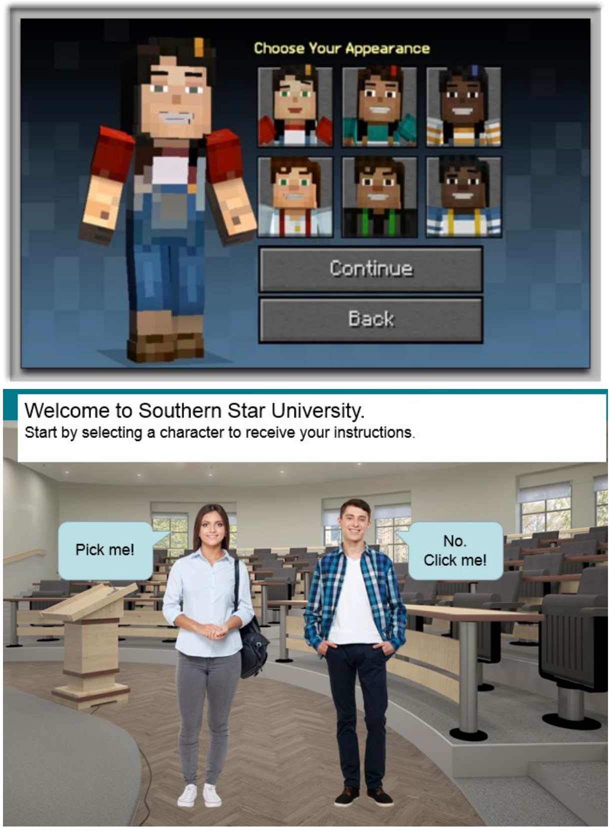

Figure 36 **Choosing appearance: Minecraft (top), TVM GLE (bottom)**

Figure 37 **Decision gates: Minecraft (top), TVM GLE (bottom)**

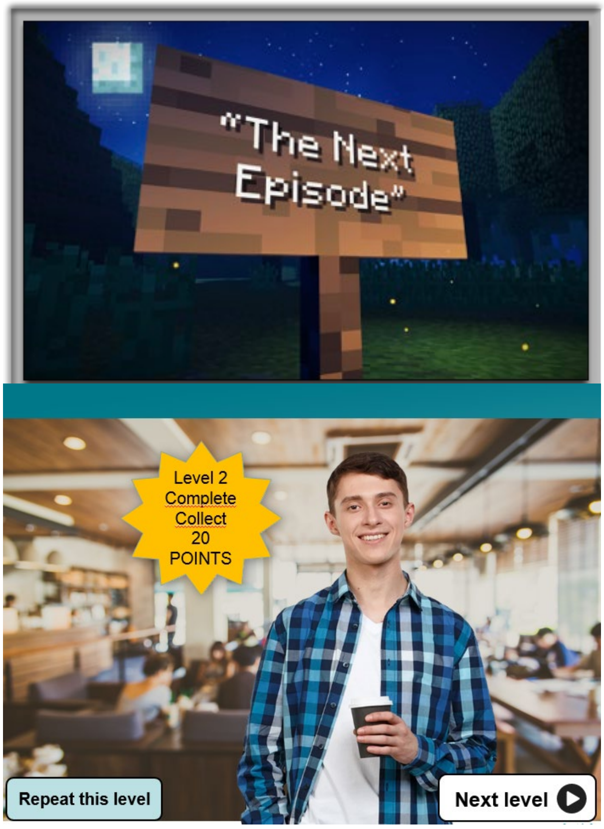

Figure 38 **Levels and repeats: Minecraft (top), TVM GLE (bottom)**

However, Minecraft is an online space where students can create programs to solve challenges. This research required a predetermined story for students to traverse. Minecraft Education Edition does allow for the teacher to create episodes for students to then create and collaborate learning coding and programming skills, although tailoring, monitoring, delivery, and data collection for the specific threshold concept in this experiment were problematic.

Smart Sparrow, a commercialised learning technology that incorporates formative assessment of concepts, was considered. Its capacity to allow educators to create learning experiences in the form of online storytelling, which deployed straight to students via a learning management system was promising. The university was investigating trialling this platform, but licence cost and lead time stalled this potential pathway.

During this investigative shopping process, conversations with the learning technology department distilled the following requirements for the GLE:

- The mechanics and structure of a game environment needed to be available in the GLE.
- The ability to employ animation of game elements.
- The capacity for learners to make personalisation choices, move around the GLE world, and make decisions.
- A non-linear pathway through the GLE.
- The seamless inclusion of data collection and surveys.

iSpring (https://www.ispringsolutions.com/) was suggested. It is an e-learning add-in package for developing training courses in PowerPoint, with embedded quizzes, surveys, and interactions. Considering the researcher's strengths in educational technology and matching these to available technology, iSpring was the best fit. The toolbar in Figure 39 shows the iSpring add-in suite including the authoring components: (1) iSpring QuizMaker; (2) narration screen recording tool; (3) iSpring content library visuals (templates, characters, backgrounds, objects, and icons) - a set of standalone tools that can be used both separately and together; and (4) components available in the publishing interface - iSpring Cloud hosting and sharing platform, with output compatible with mainstream learning management system standards (SCORM files). There was also an option to publish courses specifically to BlackBoard learning management system, the university learning management system platform where this research was undertaken.

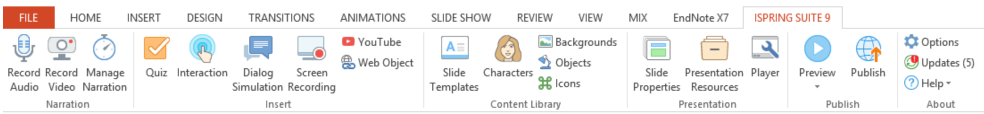

Figure 39 **iSpring toolbar in PowerPoint**

The choice of iSpring provided a digital atlas of pre-coded content (the visuals) and a development platform, which afforded the tools to create the GLE without additional coding. Coupled with the use of non-linear PowerPoint pedagogy as a resource, iSpring was the ultimate software decision. The iSpring licence was a download login, and construction of the GLE from within PowerPoint was now available.

8.5.3 Story line

All scenarios of TMV begin with the question: Would you rather have the money now or in the future? Wrapping an episodic story line with a plot driven narrative around the seemingly straightforward concept, and providing enough scaffolding to convey the content with enough latitude to discover the learning, proved a challenging exercise. To allow learners' their own discovery required clear, concise, non-ambiguous content. Given that the learner participants were going to be university students, the story line followed their subsistence needs of transport, coffee, and the goal of graduation.

Level 1 asked participants to make a choice between receiving a sum of money now enabling them to purchase a car or wait until a year from now and ride their bike to university all year before they could purchase the same car. This level introduced the concept of interest on investment.

Level 2 asked participants to invest some money and consider what return they would achieve from either simple or compound interest. With simple interest they used the interest to buy a coffee each week. With compound interest they bought the coffee machine at the end of the investment period and had never-ending coffee. In this level, they derived the formula for Future Value.

Level 3 asked participants to choose between two options of investing some money to achieve a desired amount in the future. The participants had to decide how much money to invest to pay for a graduation ticket in the future. In this level, they derived the formula for Present Value.

Level 4 was the assessment of learning outcomes and asked participants to put into practice what they had just learned, demonstrating both practical and theoretical knowledge. Participants were asked to decide between paying for a ticket now or in the future, based on the interest rate they could achieve by investing today.

The choice of themed backgrounds for each level, with complementary and consistent textures was important for familiarity and consistency, and to achieve seamless flow from one level to the next. Level 1 (Figure 40) used internal and external façades of a university. Level 2 (Figure 41) was a coffee shop. Level 3 (Figure 42) depicted a futuristic space travel scene. Level 4 (Figure 43) took the learner to a graduation picture.

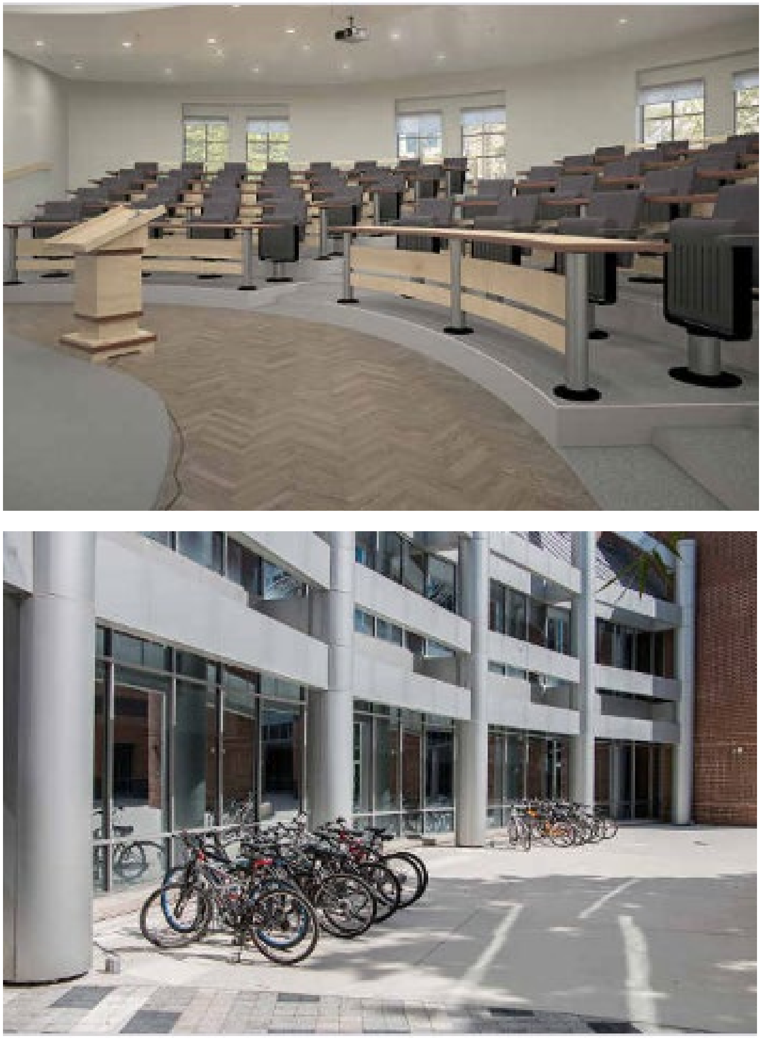

Figure 40 Level 1: University backgrounds

Figure 41 Level 2: Coffee shop backgrounds

Figure 42 Level 3: Futuristic travel backgrounds

Figure 43 **Level 4: Graduation backgrounds**

8.5.4 Characters

The iSpring character library is classified hierarchically via context, culture, and then gender. The binary gender choice of male or female dictated the need for two identical GLE streams to cover the participant's choice of either the male or female appearance avatar. The first selection point is clothing. Casual clothing was chosen as participants were to be drawn from university students. Next was age. The two brackets considered were 18-25 or 25-40 years. Both selected ended up being from the first age bracket. These avatars were revisited when later choices narrowed the availability of enough character library content in terms of stances, gestures, and expressions to cover all scenarios. The ethnicity selector availed the best effort to represent diversity. The final choices – again constrained by character library content as above – were a male Caucasian character and a female Indian character. As the GLE was built, the characters' action, directions, and emotions – the animation of the characters –

were dictated by the plot driven narrative. As noted above, ethnicity and age were reverse engineered at this point in the design, dependent on the animation availability of library content for each character.

8.5.5 Iconography

From the iSpring content library, icons were used as direction guides. Paramount here was consistency in the use of symbols: the location/placement on the screen, size, colour, and action they initiated. For example, all navigation icons were styled as shown in Figure 44 and placed in the bottom right hand corner of the screen.

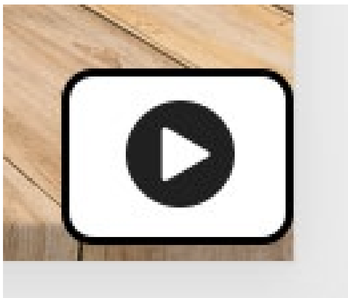

Figure 44 Navigation icon

8.5.6 Including and matching lexicon: Mapping the Gamification Alignment table

In Section 3.2.2 the Gamification Alignment Table (Wood, 2019) was developed. Ensuring all the pedagogical lexicon terms matched to gaming lexicon elements and were included to give a game like experience that students were familiar with was essential in the design thinking process. Examples drawn from the treatment are shown in Figure 45.

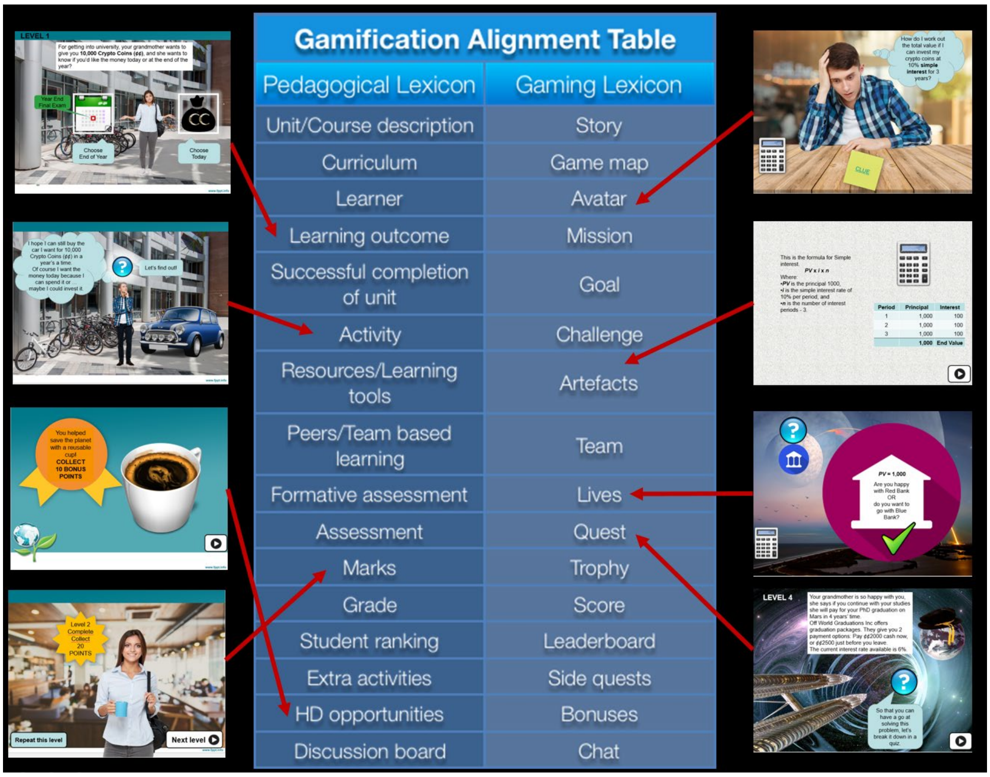

Figure 45 **Gamification Alignment Table (Wood, 2019)**

Introducing learning design as a fundamental element (Lameras et al., 2015) through mapping the Gamification Alignment Table, helped to plan how the learning design features and game properties were planned, designed, and implemented. By reducing to first principles the learning activities, outcomes, feedback, and teaching techniques, and matching these to the game attributes of rules, goals, choices, challenges, collaboration, and competition, the GLE gained cohesion and direction.

8.6 Matching the GLE treatment to the control

To ensure both groups were exposed to exactly the same content and examples, the GLE treatment version and the control version video were developed concurrently. This was imperative to ensure that the surveys administered to each group measured the same sequential experience of learning and offered both groups the same chance to learn the concept. With permission, an in-use video of TVM from a finance unit was utilised as the control video. Mediasite was used to edit the university template and add animated highlights and transitions to match the existing audio on the video. The GLE stages and examples exactly match those developed in the video (which runs 13:14 minutes). Figures 46 and 47 show example slides from the video version.

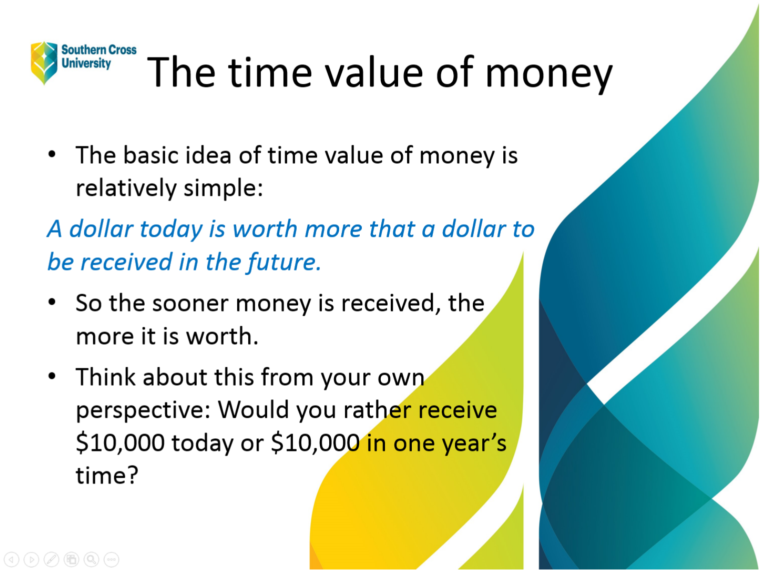

Figure 46 **Video version of the experiment: Slide 1 of 9**

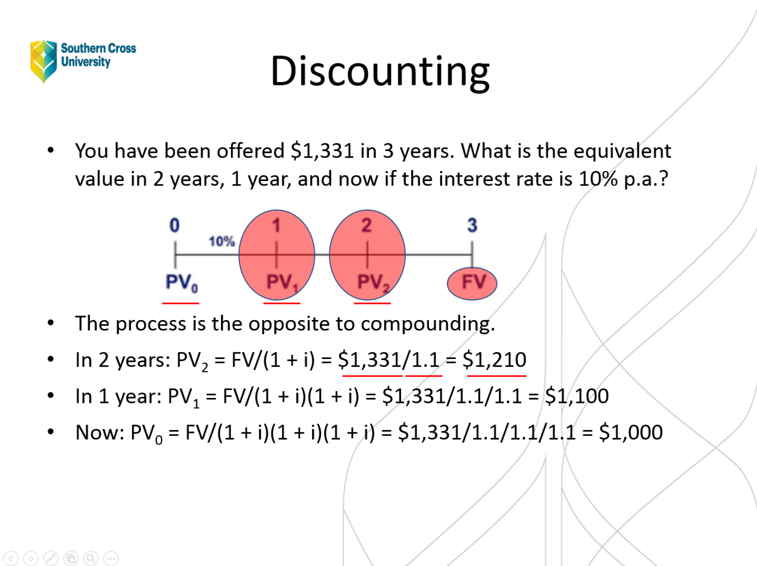

Figure 47 **Video version of the experiment: Slide 8 of 9**

8.6.1 Pedagogy: The method and practice of teaching

The pedagogy of the control group using the video is linear, flat, and unidirectional, although learners can pause and rewind. The GLE group pedagogy is non-linear and multi-directional, allowing choices, revisiting clues (hard scaffolds), and multiple repeats of levels (concepts), as well as personalisation. An environment and opportunity for analysing and evaluating the application of the accounting and finance technical threshold concepts is achieved in the GLE model.

8.7 Bringing it all together

The two versions were created in iSpring – one control group with video and one experiment group with the GLE treatment. Each version contained a lineal progression of all the components: demographic information, digital learner survey, learning experience, learning assessment, and experience survey. The experience survey (eGameflow) contained terminology that was adapted to be relevant to video control group: *game* was replaced with *video* and the integrity of the survey items remained intact and comparable across the groups. Further, social interaction factor items were removed from the survey because both the control and experimental group were single player/learner situations, with collaboration and peer discussion only available at the end via discussion board.

8.7.1 Publishing

On *MySCU* the university's learning management system (BlackBoard), a self-enrol unit site, Gamified Learning Experience (Figure 48), was created. Both the treatment and the control versions of the experiment from iSpring were published as a SCORM files. These were embedded into the site. The use of *MySCU* meant that all participant data was collected in Grade Centre as well as Evaluation: SCORM Reports, for export to excel and subsequent data analysis. In addition, iSpring provided the option for the Quiz Maker (the researcher) to be emailed with results each time a quiz from a published iSpring file was completed. This provided a backup of data as well as enabling the researcher to monitor the progress of the data collection.

The use of MySCU as a platform for conducting the experiment had multiple advantages:

- Build and editing control,
- Familiarity for participants: Contents tab including Announcements, Instructions and Files, Discussions,
- Repository of Consent Form, and
- Standalone TVM video and TVM game files to allow participants access to the alternative group's experience after completion of their allocated research experience.

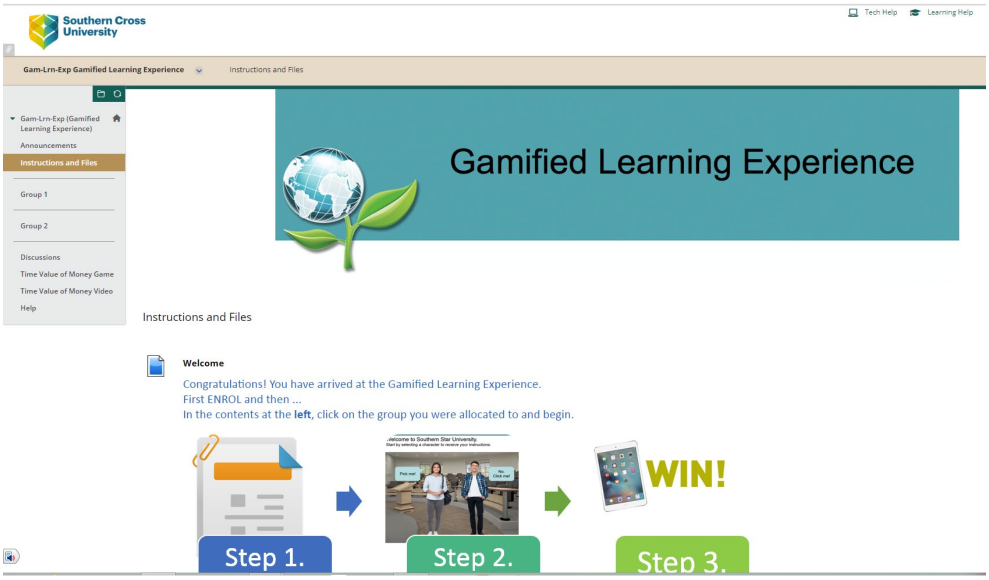

Figure 48 **MySCU Gamified Learning Experience site – landing page**

Each participant's information was captured in total for the whole experiment. This included not only survey data, but also time spent in each phase of the experiment.

8.7.2 Beta testing

As a final stage of the experiment development, the GLE treatment and video were deployed to a focus group of four students and two faculty members (the researcher's principal supervisor at the time and an eLearning designer). This process provided valuable feedback on the following items:

- Minor edits
- Survey progress markers to guide and encourage participants: "You're half way! Keep going!" and "Nearly there!"
- Survey content:
  - Participant Information and Learning Outcomes Assessment amended to include a pre and post question. This was a question chosen from previous exams for the Finance unit, where historical data was available on student results. In the pre-section the question was included as a multiple choice. In the post section, it was the same format with the addition of feedback provided on the multiple-choice question based on the participant's selection of the right or wrong answer.
  - Learning Outcomes Assessment was also amended to include an additional, harder *post* question. This question required higher order thinking skills to demonstrate evaluation of the technical threshold concept. Feedback was again given based on the selection of the right or wrong multiple-choice answer.
- Design elements were also refined to ensure clean navigation and movement from each game scene to its drill down or link, and movement between and within levels.
  - For example, aligning the elements on the final "Thank you!" screen to draw the eye in one direction instead of placing them more artistically on the page, reducing participant effort and fatigue.

One student actually did both versions (Group 1 GLE, then Group 2 video), about a week apart, and reported after the video:

> I found this a little better experience because I knew what to expect. So being familiar with the process made it easier to go through and focus more. Even though I did several emails along the way. In group 2 the questions were more ambiguous and so I had more wrong than right.

The interesting observation, here, is that the questions in each group were exactly the same. Perhaps the ambiguity experienced stemmed from lack of engagement during his re-learning process, leading to the perception of the questions being harder.

As part of the university Open Day exhibits, the stand-alone GLE was made available. This gave the researcher the opportunity to watch people engage with the experiment.

8.7.3 Call for participants

In order to recruit participants, the researcher undertook a combination of the following activities:

- Email to all Business and Business Law students,
- Target emails to business, accounting, and finance unit students, and announcements on the university learning platform, MySCU,
- Digital signage and flyers,
- Personal invitations by addressing groups of students at university events, and
- Drop in to on campus classes.

8.8 Key lessons learned

The principal researcher wore four hats: teacher, content expert, instructional designer, and educational technology designer. In the design process, it is easy to become entrenched in one of these areas, but vital to pull back to see the GLE design progress from the perspective of a different hat.

Lessons learned:

1. Seek advice from experts.
2. Beta testing is essential.
3. Watch others react to and interact with your experiment.
4. Take all this on board and make iterative changes without attachment.

8.9 Summary

This Appendix reviewed and reflected upon the researcher's development of the experiment treatment GLE by examining the checks and balances employed to ensure the reliability, rigour, trustworthiness, and credibility of the treatment; and the design considerations to facilitate replication and generalisability. The following Appendices contain: the Time Value of Money game, the Felder Silverman Learning Style Index questionnaire, the Learning Assessment quiz, and eGameFlow Survey with eLearningGameFlow.

Appendix 2 The Time Value of Money game

Click the link below to experience the Time Value of Money game and the learning assessment quiz:

https://learn.scu.edu.au/bbcswebdav/institution/courseware/projects/Business%26Tourism/TVOM/index.html

Appendix 3 Felder Silverman Learning Style Index questionnaire

DIRECTIONS

✓

1. I understand something better after I

a) try it out.

b) think it through.

2. I would rather be considered

a) realistic.

b) innovative.

3. When I think about what I did yesterday, I am most likely to get

a) a picture.

b) words.

4. I tend to

a) understand details of a subject but may be fuzzy about its overall structure.

b) understand the overall structure but may be fuzzy about details.

5. When I am learning something new, it helps me to

a) talk about it.

b) think about it.

6. If I were a teacher, I would rather teach a course

a) that deals with facts and real life situations.

b) that deals with ideas and theories.

7. I prefer to get new information in

a) pictures, diagrams, graphs, or maps.

b) written directions or verbal information.

8. Once I understand

a) all the parts, I understand the whole thing.

b) the whole thing, I see how the parts fit.

9. In a study group working on difficult material, I am more likely to

a) jump in and contribute ideas.

b) sit back and listen.

10. I find it easier

a) to learn facts.

b) to learn concepts.

11. In a book with lots of pictures and charts, I am likely to

a) look over the pictures and charts carefully.

b) focus on the written text.

12. When I solve math problems

a) I usually work my way to the solutions one step at a time.

b) I often just see the solutions but then have to struggle to figure out the steps to get to them.

13. In classes I have taken

a) I have usually gotten to know many of the students.

b) I have rarely gotten to know many of the students.

14. In reading nonfiction, I prefer

a) something that teaches me new facts or tells me how to do something.

b) something that gives me new ideas to think about.

15. I like teachers

a) who put a lot of diagrams on the board.

b) who spend a lot of time explaining.

16. When I'm analysing a story or a novel

a) I think of the incidents and try to put them together to figure out the themes.

b) I just know what the themes are when I finish reading and then I have to go back and find the incidents that demonstrate them.

17. When I start a homework problem, I am more likely to

a) start working on the solution immediately.

b) try to fully understand the problem first.

18. I prefer the idea of

a) certainty.

b) theory.

19. I remember best

a) what I see.

b) what I hear.

20. It is more important to me that an instructor

a) lay out the material in clear sequential steps.

b) give me an overall picture and relate the material to other subjects.

21. I prefer to study

a) in a study group.

b) alone.

22. I am more likely to be considered

a) careful about the details of my work.

b) creative about how to do my work.

23. When I get directions to a new place, I prefer

a) a map.

b) written instructions.

24. I learn

a) at a fairly regular pace. If I study hard, I'll "get it."

b) in fits and starts. I'll be totally confused and then suddenly it all "clicks."

25. I would rather first

a) try things out.

b) think about how I'm going to do it.

26. When I am reading for enjoyment, I like writers to

a) clearly say what they mean.

b) say things in creative, interesting ways.

27. When I see a diagram or sketch in class, I am most likely to remember

a) the picture.

b) what the instructor said about it.

28. When considering a body of information, I am more likely to

a) focus on details and miss the big picture.

b) try to understand the big picture before getting into the details.

29. I more easily remember

a) something I have done.

b) something I have thought a lot about.

30. When I have to perform a task, I prefer to

a) master one way of doing it.

b) come up with new ways of doing it.

31. When someone is showing me data, I prefer

a) charts or graphs.

b) text summarising the results.

32. When writing a paper, I am more likely to

a) work on (think about or write) the beginning of the paper and progress forward.

b) work on (think about or write) different parts of the paper and then order them.

33. When I have to work on a group project, I first want to

a) have "group brainstorming" where everyone contributes ideas.

b) brainstorm individually and then come together as a group to compare ideas.

34. I consider it higher praise to call someone

a) sensible.

b) imaginative.

35. When I meet people at a party, I am more likely to remember

a) what they looked like.

b) what they said about themselves.

36. When I am learning a new subject, I prefer to

a) stay focused on that subject, learning as much about it as I can.

b) try to make connections between that subject and related subjects.

37. I am more likely to be considered

a) outgoing.

b) reserved.

38. I prefer courses that emphasise

a) concrete material (facts, data).

b) abstract material (concepts, theories).

39. For entertainment, I would rather

a) watch television.

b) read a book.

40. Some teachers start their lectures with an outline of what they will cover. Such outlines are

a) somewhat helpful to me.

b) very helpful to me.

41. The idea of doing homework in groups, with one grade for the entire group,

a) appeals to me.

b) does not appeal to me.

42. When I am doing long calculations,

a) I tend to repeat all my steps and check my work carefully.

b) I find checking my work tiresome and have to force myself to do it.

43. I tend to picture places I have been

a) easily and fairly accurately.

b) with difficulty and without much detail.

44. When solving problems in a group, I would be more likely to

a) think of the steps in the solution process.

b) think of possible consequences or applications of the solution in a wide range of areas.

Appendix 4 Learning Assessment Quiz

Your grandmother is so happy with you for getting into university, she wants to pay for your graduation in 4 years' time. Great Graduations Inc offers graduation packages. They give you 2 payment options: Pay $2,000 cash now, or $2,500 on the day.

NB: The current interest rate available is 6%.

Formulas: $FV = PV\,(1 + i)^{n}$

$PV = FV\,/\,1 + i)^{n}$

Question 1: What is the value of the variable *n*?

Question 2: What is the value of the variable *i*?

Question 3: What is the value of the principal – *PV*?

Question 4: If you decide to invest the $2,000, what is the future value (*FV*)?

Question 5: If you decide to pay for your ticket later, how much will you have to invest to have $2,500 in 4 years?

Question 6: From your calculations, what is the best option?

(a) Pay now
(b) Pay later

Question 7: Which of the following is the definition of compound interest?

(a) Compounding is the process by which interest earned on an investment is reinvested so that in future periods, interest is earned on the interest as well as the principal.
(b) Compound interest is the same as simple interest.
(c) Compound interest is paid out in cash every interest period.
(d) Compound interest pays the same amount every interest period.

Question 8: The term time value of money refers to the concept of:

(a) The value of money changing over time due to interest.
(b) Why a dollar received tomorrow is worth more than a dollar received today.
(c) Why a dollar received tomorrow is worth the same as a dollar received today.
(d) None of the above.

Question 9: Future value measures:

(a) What a cash flow is worth at the end of a specified period.
(b) What a cash flow that is to be received in the future will be worth today.
(c) Both a and b.
(d) None of the above.

Question 10: The process of converting an amount given at the present time into a future value is called:

(a) Simple interest.
(b) Discounting.
(c) Compounding.
(d) None of the above.

Question 11: The process of converting a future value to its present value is:

(a) Spending now.
(b) Discounting.
(c) Compounding.
(d) None of the above.

Question 12: Which of the following statements is true?

(a) Future value calculations involve bringing a future amount back to the present.
(b) The future value is often called the discounted value of future cash payments.
(c) The future value factor is more commonly called the discount factor.
(d) The present value is often called the discounted value of future cash payments.

Question 13: What is the future value (*FV*) of $20,000 received 4 years for now, assuming the interest rate is 12% per year?

(a) $28,292.66
(b) $17,096.08
(c) $31,470.39
(d) $32,020.64

Question 14: You have the opportunity to receive a lump sum payment either now or in the future. Which of the following opportunities is best, given that the interest rate is 7% per year?

(a) One that pays $1,800 in 10 years.
(b) One that pays $1,200 in 2 years.
(c) One that pays $1,500 in 5 years.
(d) One that pays $1,000 now.

Appendix 5 eGameFlow Survey

Factor	Item number	Content
Concentration	C1	The gaming activities are related to the learning task
	C2	***I remained focused on the game**
	C3	***I was not distracted from the learning task**
	C4	***I was not burdened by tasks that seemed unrelated**
	C5	The workload of the game is adequate
Goal clarity	G1	Game goals were presented at the beginning of the game
	G2	Game goals were clear
	G3	Intermediate goals were presented at the beginning of each scene
	G4	Intermediate goals were clear
Feedback	F1	I received feedback on my progress in the game
	F2	I received immediate feedback on my actions
	F3	I was notified of new tasks immediately
Challenge	H1	The game provided hints that helped me with the challenges
	H2	The game provided other supports to help me with the challenges
	H3	***The difficulty of challenges increased as my knowledge improved**
	H4	The game provided new challenges at an appropriate pace
	H5	The game provided different levels of challenges tailored to my needs
Autonomy	**A1**	***I felt a sense of control and impact over the game**
	A2	***I understood the stages of the game**
	A3	***I used the opportunity to repeat stages of the game**
Immersion	**I1**	***I forgot about time passing while I played the game**
	I2	***I became unaware of my surrounding while I played the game**
	I3	***I temporarily forgot about other things while playing the game**
	I4	***I became involved in the game**
	I5	***I felt emotionally involved in the game**
Knowledge improvement	K1	The game increased my knowledge
	K2	I understood the basic idea of the game straight away
	K3	I applied my knowledge within the game
	K4	The game motivated me to integrate my knowledge straight away
	K5	I want to know more about the concept taught in the game

Note. Adapted from Fu et al.'s (2009) post validity and reliability tested instrument.

***Retained items for eLearningGameFlow**