Journal of Computer Assisted Learning

Overcoming the Novelty Effect in Online Gamified Learning Systems: An Empirical Evaluation of Student Engagement and Performance

Journal:	*Journal of Computer Assisted Learning*
Manuscript ID	JCAL-18-424.R1
Manuscript Type:	Article
Technology and Tools:	Games, Courseware, Information systems
Learning process / Pedagogy:	Problem-Based Learning, Individual learning
Paradigm:	Scaffolding, Student-Centred
Level of education :	Undergraduate
Place of learning:	Distance, Formal Learning, Informal Learning
Type of research:	Mixed methods
Research technique:	Case Study, Design Based Research
Analysis/evaluation paradigm:	Participatory Evaluation
Issues:	Knowledge, Motivation

Overcoming the Novelty Effect in Online Gamified Learning Systems: An Empirical Evaluation of Student Engagement and Performance

Abstract

Learners in the Higher Education context who engage with computer-based gamified learning systems often experience the novelty effect: a pattern of high activity during the gamified system's introduction followed by a drop in activity a few weeks later, once its novelty has worn off. We applied a two-tiered motivational, online gamified learning system over two years to a total number of 333 students. In a mixed methods research design, we used three-years' worth of longitudinal data (333 students for the treatment group and 175 in the control group) to assess students' engagement and performance in that period. Quantitative results established that students engaged and performed better in the gamified condition vis-à-vis the non-gamified. Furthermore, students exhibited higher levels of engagement in the second year compared to the first year of the gamified condition. Our qualitative data suggests that students in the second year of the gamified delivery exhibited sustained engagement, overcoming the novelty effect. Thus, our main contribution is in suggesting ways of making the engagement meaningful and useful for the students thus sustaining their engagement with computer-based gamified learning systems and overcoming the novelty effect.

Keywords: novelty effect, gamification, student engagement, student performance, computer-based learning system, meaningful

1. Introduction

Educational practitioners advocate harnessing the power of technology for student engagement (Alavi & Leidner, 2001; Chen, 2014; Dickie & Meier, 2015; Donnelly & Hume, 2015; Gourlay, 2015; Seery, 2015). Virtual Learning Environments (hereinafter VLEs), such as Blackboard, WebCT, and Moodle, are widely used for facilitating the learning of students in the higher education (hereinafter HE) sector. Yet, the uninspiring use of VLEs may lead to student disengagement and lack of motivation, affecting students' learning negatively (Means, Toyama, Murphy, Bakia, & Jones, 2009). Many instructors overlook user-specific factors that can facilitate success (Petter, DeLone, &

McLean, 2013) in the design of their online learning systems (Hassanzadeh, Kanaani, & Elahi, 2012) and simply augment or replicate traditional classroom processes online leading to disengagement (Revere & Kovach, 2011). Meanwhile, student engagement with lectures, and participation in seminars has been declining in the recent years (Holmes, 2015; Soilemetzidis, Bennett, Buckley, Hillman, & Stoakes, 2014). In a VLE, the expectation is that students proactively engage with content. However, to make VLEs more engaging, research has argued for better integration among digital strategies, learning science and relevant contextual factors (McKnight et al., 2016).

Educational gamification, which is the application of game mechanics and elements in an educational context, offers a user-centered, autonomous, and flexible learning environment (Deterding, Dixon, Khaled, & Nacke, 2011). A gamified learning system can encourage learners to pursue their own goals (Richard N. Landers & Callan, 2011) and engage in deeper-levels persistently (A. Anderson, Huttenlocher, Kleinberg, & Leskovec, 2014). Gamification is effective in other sectors such as finance, marketing, economical areas, yet it was not originally designed for an educational context (Zichermann & Cunningham, 2011). Motivation-inducing mechanisms of a typical gamified system include challenges, time restrictions, feedback, virtual status, and can engage the learners and alter their motivational state as a result of user-user and user-system interactions.

Nevertheless, gamified learning systems have limitations. Firstly, they rely on addictive, pattern-based methods, thus failing to afford a gaming experience (Deterding et al., 2011; Nicholson, 2012; Robertson, 2010). Secondly, there is lack of iterative prototyping for system ideation (Deterding, 2015). Thirdly, user characteristics and user needs/preferences are underexplored (Hamari, Koivisto, & Sarsa, 2014). There are exceptions (Davis, Sridharan, Koepke, Singh, & Boiko, 2018) but most system designers assume that users' characteristics follow gamer typologies (for example: Bartle, 1996), i.e. imaginary personae rather than data-driven profiles (Deterding, 2015). Final limitation is the distinct possibility that gamified learning systems may not sustain learners' individual interests and engagement longitudinally (Davis et al., 2018; Rodríguez-Aflecht et al., 2018), a phenomenon that we have labeled here as the novelty effect (Clark, 1983). This novelty effect has been documented in different bodies of literature: from the introduction of novel technology, the introduction of new IT systems to gamification systems (Hamari et al., 2014). Novelty effect refers to the

human tendency for heightened engagement and/or performance when encountering the introduction of a novel phenomenon, such the introduction of a new technology. In non-game contexts, introducing gamification usually results in a perceived increase in enjoyment as mundane tasks become "playful". Subsequently, user interest and engagement may gradually disappear once game elements and mechanics are no longer keeping users entertained or satisfied, a phenomenon known as the "hedonic treadmill" (Brickman & Campbell, 1971). The novelty effect is particularly relevant in the context of Computer-assisted learning whenever there is a new computer-based learning system implemented.

Thus, our contribution to the literature is twofold. Firstly, we developed a gamified online learning system that adopted a design-based approach to address the design limitations of computer-based gamified learning systems. The longitudinal iterative cycles allowed us to observe the novelty effect and generate ways to overcome its potential negative impact on engagement. Secondly, our mixed-method research design used a rich set of data to validate the effectiveness of gamification and to reveal that student behavioral engagement and performance improved over three consecutive years. Qualitative feedback suggested that gamification elements facilitated the development of learner extrinsic and intrinsic motivations to engage in learning activities, playing an important role in captivating and sustaining students' attention and efforts transcending the barrier of the novelty effect. These findings have direct implications for designers of gamified systems and the educators as well as VLE systems' developers who develop and use such learning systems.

2. Theoretical background

2.1. Gamification

Gamification (Deterding et al., 2011), is conceptually akin to *game design*, not to *games*. It focuses on how the designer's intentions and implementation choices lead to a specific change in target outcomes, such as increased learning, health, civic engagement, or job performance. Richard N Landers, Auer, Collmus, and Armstrong (2018) depict clear theoretical causal relationships between game dynamics (such as goals, competition and cooperation, freedom to fail, and many others) and game mechanics (e.g. avatars, badges, boss fights, content unlocking and others) as mapped against the users' psychological states (mediators) thus enhancing engagement or performance in learning activities. The causal pathway from gamification elements to

desired user outcomes is moderated by design-relevant and design-irrelevant personal and contextual factors (Richard N Landers et al., 2018), such as demographics and environmental conditions (Hamari et al., 2014; Rodríguez-Aflecht et al., 2018; Seaborn & Fels, 2015).

2.2. *Gamification, engagement, and the learning journey*

Student participation in a gamified learning system can be viewed as a journey that consists of discovery, on-boarding, engaging, and end game (Conejo, 2014). Most gamification studies (e.g. (Banfield & Wilkerson, 2014; Barata, Gama, Jorge, & Gonçalves, 2013; Cruz & Penley, 2014; Dicheva, Dichev, Agre, & Angelova, 2015; Hamari et al., 2014; Hanus & Fox, 2015) agree that during the journey, game components provide users with motivational affordances and thus they develop a stronger sense of competence, autonomy, and relatedness (E. L. Deci & Ryan, 2002). Whereas motivation is often viewed as a private, unobservable psychological, neural, and biological process, engagement is regarded as the publically observable behavior that results from motivation (Reeve, 2012).

We view engagement as multidimensional, highly dynamic, fluctuating, context-dependent and interactive (Goldin, Epstein, Schorr, & Warner, 2011; Lu, Huang, Huang, & Yang, 2017). The literature suggests that engagement is a three-component construct consisting of cognitive, affective, and behavioural engagement elements (Fredricks, Filsecker, & Lawson, 2016; Henrie, Halverson, & Graham, 2015). Cognitive engagement, in education setting, refers to leaners' focused efforts, such as self-regulation and metacognitive behaviours, to understand what is being taught. Affective/emotional engagement refers to feelings learners have about their learning experience and their social connections. Behavioural engagement means the observable behaviours that lead to academic success, such as attendance, participation, and coursework completion (Fredricks et al., 2016). E. L. Deci and Ryan (2002) routinely investigate these same engagement components as part elements of their Self-Determination Theory (hereinafter SDT) that can help explain users' psychological and behavioural engagement.

In SDT there is a continuum of motivations from *amotivation* in the lower-end of the continuum where individuals act passively or do not intend to act to the other

extreme: *intrinsic motivation*. In-between there are other levels of motivation such as *external regulation*, where people act only to obtain rewards or avoid punishment, *introjected regulation*, where behavior is contingent on self-esteem or guilt, *identified regulation*, where individuals perform an activity because they personally identify with its value or meaning, and *integrated regulation.* The latter is the form of extrinsic motivation that is most fully internalized and hence is said to be autonomous, as individuals identify with the value of an activity, it becomes part of their sense of self. While external, introjected, identified, and integrated regulation belong to what Deci and Ryan (2002) called extrinsic motivation, intrinsic motivation refers to doing an activity for its own sake because individuals find the activity inherently interesting and satisfying. While some game mechanics (e.g., badges, points, levels, or virtual goods), act as external rewards, other game mechanics (e.g., social graphs, teams, or content unlocking), may serve as intrinsic motivators to users who imbue these mechanics with personally important meanings (Banfield & Wilkerson, 2014). A well-designed gamification system can be efficient in on-boarding users, i.e. leveraging the desire of users to get on board with the game for potentially extrinsic reasons, such as situational interest (Rodríguez-Aflecht et al., 2018) or obtaining status and sharing accomplishments (Conley & Donaldson, 2015). As the learning continues, the learners may develop autonomy, competence, and/or (social) relatedness, i.e. intrinsic motivations. Therefore, if the gamified system is intelligently designed, it should enable the learners to transcend the external motivators and develop intrinsic motivators it can trigger a longer-term and deeper engagement among learners (Nicholson, 2012).

Based on the above reasoning, attempts to measure student engagement should be adapted to the learning context. In this study, our gamified system was implemented as a set of online learning activities. Therefore, behavioural engagement, measured by observable activity completions, would be more suitable than cognitive engagement which focuses on less observable efforts of the mind. This assertion is supported by Henrie et al. (2015) where quantitative measures were deemed appropriate and effective for studying student engagement at the activity level (p. 48). Therefore, we propose that:

Hypothesis 1: Student online engagement in a VLE system is higher in the gamified condition than in a non-gamified condition.

Educators embrace student engagement as an important educational construct because it could anticipate and predict positive student outcomes, such as academic achievement, course grades, learning, and skill development (Reeve, 2012). Several studies revealed gamification resulted in increased lecture attendance (Barata et al., 2013; Charles, Charles, McNeill, Bustard, & Black, 2011) and student participation (Barata et al., 2013; Charles et al., 2011; Li, Grossman, & Fitzmaurice, 2012), both shown to correlate positively with student performance (Adegoke, Salako, & Ayinde, 2013). Thus, student performance in the module's assessments becomes a relevant measure of engagement. Other studies have been ambivalent about the impact of gamification on student performance. For example, de-Marcos, Garcia-Lopez, and Garcia-Cabot (2016) compared different gamification approaches and concluded that educational games, gamified systems, social networking, and social gamification approaches delivered higher learning performance than more traditional approaches. Social gamification approaches in particular returned better results in terms of immediacy and for all types of assessments. In contrast, DomíNguez et al. (2013) used an experimental design to test the effect of gamification on student learning outcomes. Their results showed that overall scores and scores on practical gamified assignments were greater in the experimental group, but student performance on written assignments and participation suffered. Similarly, Hanus and Fox (2015) found that students who participated in the gamified environment had lower final exam scores. Still, other researchers (Barata et al., 2013; Goehle, 2013) found little evidence of impact either positive or negative on student performance. Seaborn and Fels (2015) concluded in their review that the effectiveness of gamification is a positive-leaning but mixed picture.

We believe that if learners are intrinsically engaged in a gamified learning system, their intrinsic motivations could sustain long-term and deeper engagement in learning, and therefore they are more likely to achieve the desired learning outcomes vis-à-vis a non-gamified experience. We thereby propose two inter-related hypotheses:

Hypothesis 2: Student online engagement in the gamified VLE is positively related to student performance.

Hypothesis 3: Student performance in the gamified condition is higher than that in the non-gamified condition.

From a cognitive evaluation theory (E. Deci & Ryan, 1985) perspective,

external rewards offered by many gamified elements may very likely erode intrinsic motivation, resulting in poorer performance. This "crowding-out effect" was supported by a study of (Hanus & Fox, 2015) where gamification (external incentives) undermines motivation, effort and empowerment resulting in lower grades in a final exam. Nevertheless, a meta-analytic study (Cerasoli, Nicklin, & Ford, 2014) indicated that external incentives stimulating extrinsic motavtion and intrinsic motivations are not necessarily antagonistic and should be best considered simultaneously. The research showed that intrinsic motivation became more salient when external incentives were indirectly tied to performance. We chose a self-report survey as our qualitative measure to capture evidence of the interplay between extrinsic motivation and intrinsic motivation.

2.3. *Addressing the weaknesses of gamified learning systems*

We adopted a design based research approach to gamification, characterised by an iterative cycle of design, enactment and analysis and redesign (Barab & Squire, 2004) to eliminate known weakness of online gamified learning systems. A common gamification design limitation is that it fails to afford gaming-characteristic experiences (Deterding et al., 2011; Nicholson, 2012; Robertson, 2010) and lacks in game design pattern choices. We addressed this by improving design choices to suit a greater range of learners and by providing a clearer "game" narrative through regular communications. Another limitation has been the dearth of formative research in educational gamified systems and a lack of iterative prototyping for system ideation (Deterding, 2015). To address this, we implemented the gamified learning system over two years, collected longitudinal data, and asked users for voluntary feedback regarding module contents.

A limitation that is not as prominent in the literature on gamification and yet it affected our system's iterative design is the "novelty effect" as illustrated by Hamari et al. (2014) which affected our students' engagement and performance in the first year of the gamified learning system. Novelty effect is the tendency for user engagement to initially improve during the introduction of a novel phenomenon, only to drop once the phenomenon becomes familiar. Novelty effect has been reported in several empirical studies (de-Marcos et al., 2016; Hamari & Koivisto, 2015a; Hanus & Fox, 2015). Hamari and Koivisto (2015a) studied demographic differences in perceived benefits

from an exercise gamification service, Fitocracy. They found that gamification could have some novelty value, causing perceptions of usefulness and enjoyment to be higher in the beginning and then to fade the longer the user continues using the service.

The novelty effect can have a positive impact; it is useful in order to get users to engage with a computer-based gamified learning system as users become curious and want to try the system. However, if the observed positive effects of gamification are attributed solely to the novelty effect, continued exposure to the gamified system would transform the novel experience into the mundane, thus removing from users the initial excitement to the experience of the novel phenomenon (Clark, 1983). Consequently, learners would end up being turned off by the gamified system, resulting to the opposite of what the gamified system was implemented for (van Roy & Zaman, 2015). The current literature does not explicitly inform designers of the impact the novelty effect may have on gamified systems, how long it may persist, and what are the ways designers may overcome its impact and maintain user engagement (Hamari & Koivisto, 2015b). The decrease in engagement can be severe if the system designers have a poor understanding in how to design the game elements to enhance the user experience. We therefore hypothesize that in our data we will find evidence to support:

Hypothesis 4: The novelty effect influences student engagement in a way that causes engagement to decline across time.

Knowing that the new features of the gamified system would potentially trigger the novelty effect and temporarily increase student engagement and enjoyment, the aim of any gamified system over the long run would be to sustain student engagement throughout the module duration thus overcoming the drop in engagement once the novelty effect wears off. We argue that the iterative cycles, which incorporate improvement on the gamified module design, would reduce the impact of the novelty effect, leading to the following hypothesis:

Hypothesis 5: Novelty effect in the second iterative gamified VLE would be lower than that of the first iterative design.

3. Methodology

3.1. Context

A gamified, online learning system was designed and implemented on the institution's VLE (Moodle) for two consecutive academic years (2015-17) at a post-1992 university in the United Kingdom. The module targeted was the Personal and Professional Development (PPD) module; its aims were to educate second-year undergraduate learners about Business Communication and Research. It covered four themes: self-awareness, professionalism, job acquisition, and business research methods. The teaching team consisted of twelve tutors, including the module leader. Each tutor was responsible for 12 to 16 students. There had been two long-standing issues with PPD: limited contact hours and low student engagement. We attempted to overcome these issues by developing a gamified learning system in order to make the module more interesting, engaging, and fun. The team used the VLE to create a gamified learning system with a clear "game narrative" and gamification elements such as quests, levels, leaderboards, and badges. Figure 1 shows a comparison between the traditional PPD in 2014-15 where the VLE was used as depository and the PPD in 2015-16 where the VLE was gamified.

Insert Figure 1 here

The learning system was two-tiered: *Essential Learning* (EL) and *Super Learning* (SL). EL activities (ELs) and SL activities (SLs) were provided over twenty-four weeks across two academic terms in each academic year (term 1: weeks 1-12; term 2: weeks 13-24). Both ELs and SLs were aligned with the module's learning objectives. ELs were blended with an offline *flipped classroom* setup and were compulsory. ELs introduced the students to content covered in the module, utilizing short texts, quizzes, and video clips from the public domain (See Figure 2 for examples of ELs).

Insert Figure 2 here

All ELs were available on Moodle at the beginning of Term 1 but were linked to specific deadlines over the academic year. SLs were optional and pertained to three different levels of difficulty following Bloom's taxonomy (L. W. Anderson,

Krathwohl, & Bloom, 2001). SLs were designed to challenge high ability learners while giving them flexibility and autonomy in the learning process. The expectation was that learners who completed SLs would be intrinsically motivated to do so as completing the SLs would not necessarily provide any fundamental advantage in summative assessment performance. Thus, SLs (with a few exceptions) were not bound by deadlines. *Points, badges* and *leaderboards* were used as motivators to reward students for achievement (see Figure 3).

Insert Figure 3 here

Each SL was assigned points, depending on difficulty level. Various badges were used for different kinds of achievements. Every three to four weeks, a leader-board, which included the top Super Learners, was announced to recognised their achievements. Lists of 2015-16 ELs and SLs are included in the Appendix A and B.

3.2. Gamification design

As explained in section 2.3, we employed the design-based approach to our gamified learning system and there were two iterations in this study where we went through stages of design, enactment, analysis and redesign.

3.2.1. The first iteration.

The design of the first iteration was based on a framework proposed by Werbach & Hunter (2015), which includes six steps: 1) defining system objectives, 2) delineating target behaviors, 3) describing players, 4) devising activity cycles, 5) don't forget the fun, and 6) deploying the appropriate tools.

In the first iteration, we assumed that the user population consisted of a typology of achievers, explorers, socializers, and killers (Bartle, 1996). Assuming SDT holds true we designed learning activities that catered for all types of users while aiming to develop their autonomy, competence, and/or (social) relatedness. To tap into the learners' need for autonomy, learners had freedom to choose what, when, and where to engage in the gamified learning system (E. L. Deci & Ryan, 2002). To give learners a sense of competence, common extrinsic gamification tools such as badges

and leaderboards were used to reward achievement (E. L. Deci & Ryan, 2002). To give learners a sense of relatedness (E. L. Deci & Ryan, 2002) and social engagement, tasks were designed to allow them to co-create knowledge as well as to provide opportunities for individuality (Wood & Reiners, 2012) using tools such as Wikis and Forum (authors' reference to be added).

When the ELs and SLs were launched, they were presented to learners as challenges within a competitive longitudinal framework. A points-based competition was used as the unifying narrative around which the learners' learning journey was framed and the activities were aligned. Appendix C shows a variety of game design elements used in the EL and SLs (adapted from Blohm & Leimeister, 2013).

Success was defined in two ways: 1) learners getting on board with the learning activities of the gamified system and stay engaged across time and 2) learners achieving improved student performance. When analyzing data of student engagement and performance in the first iteration, we were confident that the gamification intervention changed students' behavioral engagement in online learning and consequently, their module performance (Author's reference to be added). The intervention demonstrated success in student engagement and performance (authors' reference to be added) and therefore the gamified online learning system was continued in 2016-17 with improvements. However, we were aware that system improvements needed to be made among other things to address a drop in engagement observed towards the end of the first semester; a drop that we attribute here in this work to the novelty effect.

3.2.2. The second iteration

In the second iteration, we collected user information and asked users for voluntary feedback regarding system improvement and activity design throughout. Several actions outlined in Table 1 were taken at both system design and enactment stages in the second iteration.

Insert Table 1 about here

Firstly, the first-year student engagement and performance data were used as formative research for the second iteration. The student background information collected in the first year suggested that learners from different backgrounds engaged differently (authors' reference to be added) and as a consequence the design pattern choices and learning activities were expanded and diversified in the second iteration to suit preferences of learners from diverse backgrounds (Koivisto & Hamari, 2017). As a result, the number of ELs increased from 14 in 2015-16 to 16 in 2016-17 and the number of SLs increased from 37 in 2015-16 to 56 in 2016-17 on Moodle. Secondly, using the principles of user-centered design and a student-centered learning approach (Baeten, Kyndt, Struyven, & Dochy, 2010; Gulliksen et al., 2003), we asked learners to give voluntary feedback on their experiences of the gamified VLE. Thirdly, we identified the most and the least popular learning activities in the first iteration (based on activity completion rates), and in the second iteration we promoted the popular ones and removed the least popular ones. This action was supported by anecdotal student feedback on which activities students thought were useful. Fourthly, we developed a clearer narrative in the second iteration, to facilitate the on-boarding process of our learners onto the gamified system using more sustained communication to enhance engagement. These measures aimed to minimize the moderate novelty effect (drops in engagement) noticed in the first iteration (authors' reference to be added). In the communications, we reminded learners that the optional SLs would help them learn "above and beyond" what was essential. Completion of SLs would be rewarded with points, badges, and leader board and participation in SLs could enhance the quality of the two summative assessments. We also set a clear goal (Locke & Latham, 1990) for students in the marking criteria by stipulating that EL completion contributes to final grade. For example, learners were told, "for good and excellent engagement, a student needs to complete at least 70% of ELs" as opposed to "Your EL completion is a major part of the engagement." Finally, the module leader instigated regular, weekly communications with

students in the second year, highlighting featured SLs and emphasizing the importance of ELs and SLs to their assessments.

3.3. Sample and Data Collection Procedure

Comparable student background data are available for the cohorts participating in the gamified learning system (i.e., 2015-16 and 2016-17) but are missing for the non-gamified delivery. However, the university has used the same admission criteria for the last five years and all three student cohorts undertook the same program of study. While, the 2014-15 student background information is unavailable, the data we collected in 2015-16 and 2016-17 (see Table 2) indicate that the gender composition and percentage of international student were similar. The three cohorts were comparable in size, all large cohorts, and the data on VLE engagement and performance for the non-gamified cohort in 2014-15 is identical to the two cohorts in the gamified delivery. Thus, we assumed that all three cohorts were broadly similar in terms of prior student performance.

Insert Table 2 here

For data collection between 2015 and 2017, we informed students that data about their background information, online learning engagement and module performance would be collected and analyzed in an aggregated form, to improve the module design. Participation in the gamified online learning system was voluntary and students were provided an opt-out option. Therefore, the sample size on different variables varied from 107 to 165 in academic year 2015-16, and from 110 to 168 in academic year 2016-17. Quantitative data analysis was conducted using SPSS version 21.0 (IBMCorp., 2012)

3.4. Measures

To evaluate the effectiveness of the gamification intervention and system iterations, we used a pragmatic, mixed methods approach and utilized a range of measures, quantitative and qualitative, the former aiming to assess significance of the results while the latter aiming to understand the qualitative nature of the results. The aim was to triangulate our results; while the first three hypotheses derived from the literature were explanatory, the fourth and fifth hypothesis were exploratory. We wished to examine a complex phenomenon that is only

partially addressed in the literature; the novelty effect caused by the introduction of a gamified learning system and the means to overcome it. As a result, we utilized qualitative data in order to examine the motivations of students to engage with our learning system.

Engagement and performance data were obtained from four modules on Moodle, including the non-gamified PPD 2014-15 module, the gamified PPD 2015-16 and 2016-17 modules, and another non-gamified 2015-16 module (pseudo name "CMC") which was an unrelated yet highly engaging non-gamified business module for second-year undergraduates. The CMC module acted as a control group to check the levels of engagement and performance with a traditionally-delivered model which was considered an exemplar in terms of engagement among modules delivered more traditionally.

As the gamified system was embedded in Moodle, we collected our preliminary data generated by Moodle and conducted pre- and post-processing of the data for our hypothesis testing. The pre-processing of data was embedded in the structure of EL and SLs by pre-defining the Moodle-based activities as Essential Learning and Super Learning according to their pedagogical significance. Therefore, the students' views and completions of these two sets of learning activities were analyzed respectively.

In terms of the post-processing of data, we processed the data according to the different hypotheses we were testing. Since our hypotheses were directly related to the observable, behavioural aspects of student engagement, we created two proxies, "process" engagement and "results" engagement. These two engagement proxies are different: in "process" engagement a student may view a learning activity several times, but not necessarily complete the required task in the activity. The use of proxies to capture behavioral engagement is common in other online learning studies (Aluja-Banet, Sancho, & Vukic, 2017; Guo, Kim, & Rubin, 2014).

For hypothesis 1, we used "process" engagement data based on views of a learning activity (an umbrella term that includes any module-related item posted on a module's Moodle site). For hypothesis 2&3, we used "result" engagement data of student learning activity completion rate, by activity. For hypothesis 4, we recoded the "result" engagement data used in hypothesis 2 and used student learning activity completion by week for hypothesis testing. Finally, for hypothesis 5, we used both "process" and "result" engagement data to examine the effectiveness of system iteration and improvement.

3.4.1. View count on learning activity (Aca. Yr 2014-17)

The term 'learning activity' is used as an umbrella term that includes any module-related item posted on a module's Moodle site. A learning activity can be a file (e.g., pdf, excel, word, ppt), a folder with files, a URL (more commonly used by modules with traditional ways of delivery and use VLEs as repository), feedback, assignment, quizzes, forum, or wiki (as designed in the gamified module). We were able to obtain data on Moodle regarding views of each posted learning activity (but not who viewed or when an activity was viewed) for three cohorts of PPD and CMC. We suggest that views count on each learning activity is an indicator of "process" engagement as opposed to "result" engagement because students could view a learning activity several times without completing it. Table 3 presented the descriptive statistics of views on the learning activity in each module.

Insert Table 3 here

3.4.2. Number of EL and SL completion (Aca. Yr 2015-17)

This measure was used for "result" engagement, representing observable behavioral engagement in completing a learning activity. For engagement in an online learning activity (coded A[*i*]), "1" was coded for an activity completion and "0" for non-completion. Therefore, the number of EL and SL completion for each student was calculated. The date and time of an activity completion was also recorded. Hence, the student learning activity completion rate both by activity and by week were captured and tested in hypotheses 2 to 5. The descriptive statistics of "result" engagement are shown in Table 4.

Insert Table 4 here

3.4.3. Module performance (Aca. Yr 2014-17)

The module assessment, consisting of portfolio 1, 2, and module engagement, was the same in three cohorts, with minor changes in weighting of each component in 2016-17. Therefore, the module performance data allows us to test the effect of gamification on student performance. The term 1 assignment, Portfolio 1, assessed students' employability; it

required students to develop a personal branding video, conduct a mini-research on current graduate job market, pursue extracurricular activities with evidence, and reflect on a chosen extracurricular activity (i.e. networking) using critical incident analysis. Portfolio 2 assessed basic research skills. Students were required to write a small-scale business research project based on their group research work in Term 2. In terms of engagement, students were assessed across two terms based on class attendance and contribution to two group presentations in 2014-15. In 2015-17, engagement was assessed by class attendance, contribution to two group presentations, and completion of ELs. Engagement in SLs did not count towards the final grade classification.

Insert Table 5 here

3.4.4. Control variables (Aca. Yr 2015-17).

We included gender (Male = 1; Female = 0), prior performance, and class attendance as control variables to test the relationship between online learning engagement and student performance. From Table 2, it seemed that in both cohorts, the sample included was gender-balanced. As to prior performance, we obtained student performance in the Year 1 PPD module (107 data points) for the 15-16 data and accumulated Year 1 GPA (110 data points) for the 16-17 data. Finally, students' class attendance data was obtained from the university's web portal (see Table 6).

Insert Table 6 here

3.4.5. Qualitative feedback (Aca. Yr 2016-17)

We collected qualitative feedback from forty-four students from the second iteration of the gamified system at week 20 towards the end of the second term and we asked three questions related to engagement and non-engagement in ELs and SLs: "Why did you sometimes not engage in ELs?" "Why did you keep engaging in ELs?" and "Why did you keep engaging in SLs?".

Content analysis methods include applying existing coding schemes to categorizing the data (Clarà & Mauri, 2010). The purpose of gathering qualitative feedback in this study has

been to explore the interplay between extrinsic motivation and intrinsic motivation from students' perspective. Thus the data was coded based on the concepts from the SDT continuum. The analysis thus followed the general principles of an empirical content analysis (Patton, 2002) and was inductive in nature. The data were analysed to coalesce against the different types of motivation identified by the SDT theory through a process of data abstraction from the manifest and literal content to its latent meanings (Erlingsson & Brysiewicz, 2017). Two researchers interpreted the data and went through the same process of abstraction. Table 7 shows an example of analysis leading to higher level of abstraction:

Insert Table 7 here

This process enabled that the researchers' reasoning process was directly based on the empirical data.

4. Results

4.1. Process engagement in gamified versus non-gamified conditions

Hypothesis 1 stated that student engagement in the VLE would be higher in the gamified conditions than in the non-gamified condition. We examined "process" engagement, view count on learning activity, as an indicator. From Table 3, it is found that in the two gamified conditions, each of the learning activities attracted more "traffic" (i.e. student views (see column **(c)** and **(c/b)**). Also, the average view count per learning activity was higher in the gamified modules (352.82 and 290.75 views) than in the non-gamified modules (143.32 and 204.92 views). Moreover, the view count per activity for an average student in the gamified conditions (2.10 and 1.76 views) was higher than that in the non-gamified conditions (0.77 and 1.19 views).

To test Hypothesis 1, one-way ANOVA analyses were performed. In Table 8, there was a significant difference on average views per learning activity (F (298) = 3.74, p = 0.012). Especially, post hoc analyses using the Scheffé post hoc criterion for significance suggested that the average view count per learning activity in 2016-17 (M = 352.72, SD = 445.61) was significantly higher than that in 2014-15 (M = 143.32, SD = 103.86). In addition, there was a significant difference on views per learning activity for an average student (F (298) = 4.05, p = 0.008). Specifically, post hoc analyses suggested that the average view count per learning

activity for an average student in 2016-17 (M = 2.10, SD = 2.65) was significantly higher than that in 2014-15 (M = .79, SD = .57). We therefore can reasonably conclude that student online learning engagement was higher in the gamified conditions than that in the non-gamified conditions, including the CMC module which was an exemplary non-gamified module in terms of student engagement and performance. Hypothesis 1 was supported.

Insert Table 8 here

4.2. Result engagement & student performance

Hypothesis 2 stated that student online engagement in the gamified VLE is positively related to student performance. We performed hierarchical regression analyses using the 2015-16 and 2016-17 PPD module data respectively. Table 9 and 10 showed that completion of online learning activities, whether it is EL (Model 2) or SL (Model 3), or both (Model 4), improves student performance, controlling for gender, class attendance, and prior performance (a prior module, PPD1 performance used in 15-16 data while accumulated GPA used in the 16-17 data). Therefore, Hypothesis 2 was supported.

Insert Table 9 about here

Insert Table 10 about here

Hypothesis 3 stated that student performance in the gamified conditions is better than that in the non-gamified condition. To test this hypothesis, we used one-way ANOVA to test the average module performance among two gamified PPD modules (2015-17) and the non-gamified PPD one (2014-15). Table 11 showed the differences in mean scores. Using the Scheffé post hoc criterion for significance, we found that there was a significant difference between the module mean score of 14-15 and those of the other two academic years. However, the module average for 2015-16 was not significantly different from the module mean for 2016-17, meaning student performance did not differ significantly despite the improvements in the gamified system. The results above support Hypothesis 3.

Insert Table 11 here

4.3. Impact of novelty effect in the two gamified iterations

Hypothesis 4 stated that the novelty effect influences student engagement in a way that engagement would decline over time. Figure 4 to 7 showed patterns of student engagement in ELs and SLs in PPD in two academic years. From Figure 4 and 5, the completion rate for an average EL activity, generally speaking, increased from 53% (87.86/166) in academic year 2015-16 to 78% in 2016-17 (130.76/168). Figure 6 and 7 showed patterns of SL completion rate by activity. The completion rate for an average SL activity, increased from 23% in academic year 2015-16 (39.43/166) to 29% in 2016-17 (49.01/168). The bumps and dips reflected different levels of difficulty in learning tasks. Feedback from students suggested that the SL completion depended on student perceptions of the usefulness of an SL activity.

Insert Figure 4 here

Insert Figure 5 here

Insert Figure 6 here

Insert Figure 7 here

Figures 4 to 7 showed percentage of student completion on EL or SLs, however, they did not show date of completion. Although ELs and SLs were introduced in a linear fashion, we subsequently realized that their completion time appeared to be unlinked to the order they were introduced. That was unexpected as we had assumed that if students were motivated by the gamification aspect they would complete activities as they are released, i.e. by the deadline in order to get the points. Thus we recoded the data for each learning activity based on the actual week when a student completed it. Figure 8 and 9 showed the number of EL/SL completion by week in two academic years, indicating that student "result" engagement (i.e. activity completion) started high in both terms (week 1 and 13), decreased gradually, and

then went up again towards the end of each term (week 11 and 24). Furthermore, by comparing Figure 8 and 9, the novelty effect seemed more prominent in the 2015-16 data than in the 2016-17 data and more prominent in the Term 1 (e.g. drop of engagement after Wk 4) than in Term 2. This seems to partially support the negative impact that novelty effect has on engagement however, it also indicates that by the second iteration of the gamified condition the novelty effect was mollified.

Insert Figure 8 here

Insert Figure 9 here

Hypothesis 5 stated that the novelty effect would be less prominent or may even disappear in the second iteration of the gamified condition compared to that in the first iterative design. This means student engagement should be more sustainable across time in the second iteration (e.g. 2016-17). Regarding the process engagement data, in Table 12, ANOVA test revealed no significant differences on either average view count per learning activity or average view count per learning activity for an average student between the 2015-16 cohort and the 2016-17 cohort (see Table 12). The results strongly suggest that students' process engagement increased as a result of the online system's improvements, but not at a statistically significant level.

Insert Table 12 here

With regards to result engagement, we used student completion rate per learning activity as a data point (see Figure 4-7) and conducted an independent samples t-test on the student completion rate between the 2015-16 and the 2016-17 learning activities. Table 13 showed a significant difference between the 2015-16 cohort and 2016-17 cohort on EL completion rate ($p < .000$), indicating that indeed the improvements resulted in statistically higher engagement. However, differences in the SLs' completion rate between the two cohorts were not significant, indicating that the proportion of students who may be intrinsically motivated remained relatively steady.

Insert Table 13 about here

Overall, it appears that in the second iteration of the online learning system the drops in engagement are nearly non-existent (the only exception being Week 12, the end of Term 1) thus suggesting that the novelty effect has been eliminated. This observation seems consistent for both ELs and, to a lesser extent, SLs. The even spread of activity completion indicates that in the second iteration the system was applied and implemented more successfully and locked the students for longer in the cycle of engagement, well beyond onboarding and well into the end point of the module. Thus, in 2016-17 we witnessed more sustained activity. This observation leads to the inference that in the second iteration, other factors came into play to sustain student online learning engagement. Thus Hypothesis 5 was supported.

However, this left us with one last question; why student engagement did not go down when the novelty wore off during the second iteration? We searched for answers in our qualitative data, examined in section 4.4.

4.4. What sustained engagement in the VLE learning?

As informed by the gamification design literature, the increased engagement was due to the improvements on the gamified system, which addressed a number of game design issues in the second iteration, including the novelty effect. After the interpretative content analysis, the data is summarized and presented in Appendices 4 and 5.

While many responses showed that students were extrinsically motivated to engage in both ELs and SLs, the types of extrinsic motivation differed markedly. ELs were viewed as compulsory learning, instrumental to their module performance. For them the gamified elements did not seem particularly relevant. Though some students thought SLs were compulsory and instrumental to assessment performance, more students engaged in SLs because of the gamification elements. That is, the gamified motivational learning system provided challenges, rewards, and opportunities to compete with other learners, and that was an attractive extrinsic motivator for students to engage with SLs.

Another remarkable insight from the data related to SDT's identified regulation concept. ELs and SLs seem to have tapped into students' self-valued goals which afforded the activities with personal importance. Students wanted to engage in these learning activities because they wanted to understand the subject, learn new things, and find out if they are right

or wrong. Learners were locked into the gamified learning system because of the perceived learning benefits. That is why perceived usefulness was a frequently cited reason for engagement in ELs and SLs (see Tables 14 & 15). Students found ELs and SLs useful in understanding the module topics and/or refreshing their understanding of key concepts. However, most students reported that the usefulness of ELs is linked to assignment completion (short-term goals) whereas most students perceived SLs useful because SLs completion improved their skills and knowledge development (long-term goals).

Thus it seems that our online gamified learning system achieved considerable sustained engagement primarily because it was perceived useful but also because of the triggering of intrinsic motivation via SLs. The motivational affordances from the gamification design clearly affected students' psychological state. The majority of students in SL perceived learning as a challenge, fun and emotionally uplifting.

Figure 10 summarises student responses as to why sometimes students did not engage in ELs. Based on 53 answers provided by 44 students, the two main reasons were commitment to other modules (37.74%), and forgetfulness (18.87%). PPD modules were not perceived as important as other subject-specific modules. Also, the EL completion is a portion of the engagement assessment that is only 10% of the final mark or grade value. Some students may choose to prioritize other learning activities over ELs when being overloaded with module work. The data indicates that for more than half the students, lack of engagement was the result of forgetfulness or commitment to other modules overwhelming engagement with the PDP module. It appears that improved engagement with the gamified system in the second year, though not statistically significant enough, may well be linked to the weekly communications by the teaching team rather than any other improvements in the system.

Insert Figure 10 here
---

5. Discussion

5.1. Gamified VLE design implications

While it is assumed that in the digital era, teacher practitioners would be competent in using educational technologies, research shows that general technological competences (e.g., the ability to navigate commonly-used hardware and software) do not guarantee competence

in effective pedagogical and educational use of technology (Uerz, Volman, & Kral, 2018). McLaughlin (2013) revealed, for example, a great variation in Scottish HE academics' use of VLE tools. Most educators would use VLEs for file storage, posting announcements, and delivering learning materials, but would use less VLE reports to track student progress or to engage students in collaborative activities via discussion boards, Wikis or other collaboration tools. Respondents also acknowledged that while VLEs have the potential to enhance the student experience, there is a need to develop expertise in developing VLE systems that enable and realize that potential.

Our research contributes to educational practice and computer-enabled learning by inviting practitioners to reconsider their approach to developing online learning systems. Specifically, we suggest that an iterative process in designing a computer-based gamified learning system can help iron out the flaws in the original design of the system. Instead of treating VLEs as file repositories, by developing a "game narrative" which is supported by VLE elements can successfully and sustainably deliver meaning in the VLE context. An online gamified learning system must be embedded in the curriculum to develop a sensible narrative and transcend the novelty effect, inherent in its introduction. This approach to designing a system is independent of the VLE; our system was implemented in Moodle but with reasonable adjustments it could easily be applied in other VLEs, such as Blackboard and WebCT.

Evidence of sustained engagement was found in both the ELs' and the SLs' data. However, the meaning of engagement with the VLE differed: for students focusing on ELs, it was an instrumental, extrinsically-motivated learning system that helped them do better in the module while for the learners who engaged with SLs the system afforded a different range of motivations beyond the perceived usefulness and instrumentality of the system. For a substantial proportion of the cohort in the second iteration, the engagement with the gamified learning system was intrinsically driven and transcended the novelty attraction of a gamified online learning system to become a habitual, playful, game-like activity, overcoming the novelty effect.

5.2. Creating meaningful gamification

This study enhances our understanding of gamification research through our quantitative findings, by suggesting the extent to which gamification influences student engagement. The

number, level of engagement and performance of students in the gamified deliveries far outstripped those of the students in the non-gamified deliveries. Students seem to be attracted to the unique VLE and actively participated in learning activities. Overtime, there seem to be a point of saturation, as shown in the case of the first iteration of the gamified system, where once the students got used to the gamified elements in the VLE, their engagement with ELs in particular wanes, indicating that the novelty effect on-boarded students onto the system but eventually led to negative impact on engagement and performance. However, in the second iteration of the gamified system we were able to sustain engagement with the ELs and the novelty effect of the gamified learning system only had the positive on-boarding impact and we experienced no drop in engagement once the novelty wore off. It seems that once the novelty of the gamified system wears off (Hamari et al., 2014), common extrinsic motivators of gamification design (e.g. points, badges, and leader board) lose their influence on student engagement, and were uniformly absent in the qualitative data we obtained with regards to ELs. For some students, the saturation of extrinsic motivators results in reduction of engagement, which explains why Hypothesis 4 was only partially fulfilled. Thus, not every gamified learning system can provide a meaningful, sustained engagement to the students. Especially, if a system focuses only on gamified elements that resemble external motivators, it will very likely be negatively affected once the novelty wears off. The work of Richard N Landers et al. (2018) suggested that apart from the gamification elements, design-irrelevant context factors (e.g. pedagogical factors) contributed to sustained student engagement. This idea, also supported by Glover (2013), that although gamification can make learning more engaging, it should not be viewed in isolation to other tools and methods.

In our gamified learning system, we attribute its relative success to an integration of gamified learning design and pedagogical principles to achieve a "meaningful gamification" (Nicholson, 2015) experience, which ultimately satisfies learners' psychological needs of competence, autonomy, and relatedness (Leese, 2009). If a gamified learning journey consists of discovery, onboarding, engaging, and end game (Conejo, 2014), we may conclude that a gamified learning system helps greatly with onboarding users, but on its own it cannot keep them once the novelty effect is gone. In our case, the learners were locked into the system because they perceive "meaningfulness" in their learning experience beyond the novelty of a gamified learning system.

In the recipe for meaningful gamification, Nicholson (2015) proposed six elements: play, choice, exposition, information, engagement, and reflection. In our gamified learning system, "play" and "choice" were reflected in those optional SLs were designed to allow for freedom of choice and to facilitate the freedom to explore and the possibilities to fail within safe boundaries. In terms of exposition, a gameful narrative for student learners was created and "the rules of the game" were made clear from the beginning. Regarding "information," the teaching team's regular communication about the importance of learning activities as well as the quality and relevance of the learning activities to the module's learning outcomes were well received by students. In addition, tutor feedback was provided to students' submitted work, and therefore the "engagement" element was successfully incorporated as qualitative student feedback suggested that they found SLs useful not only for assessment preparation but also for personal development and found that ELs facilitated their learning in the seminar and helped them engage with the sessions. Finally, the "reflection" element was evident as students expressed that both ELs and SLs have contributed to learning improvement. All these elements create conditions for "meaningful gamification" (Nicholson, 2015), shifting students' regulation from non-self-determined (i.e. extrinsic motivation or introjection) to self-determined (i.e. identification, integration, and intrinsic motivation) (Ryan & Connell, 1989), which was thought to intrinsically motivate students and therefore deepen the long-term engagement and learning experienced by the users.

5.3. Engagement: How It Is Measured Matters

An unexpected insight from this research provides a cautionary note: depending on the way student engagement is measured one can evaluate quite differently the effectiveness of a gamified system. When we originally used "views of a learning activity" as an indicator we found that the "traffic" in gamified modules was higher than that in non-gamified modules (Table 8). However, traffic (visits) does not mean actual engagement in terms of learning activity completion. Then we switched to users' activity completion (rates) as a second, more robust indicator of learning engagement (Figures 4 to 7). Even though this measure showed actual engagement, it did not account for the time dimension, i.e. when a student completed a learning activity. Therefore, a third indicator, number of activities completed by week, was used (Figures 8 and 9) which allowed us to notice the novelty effect, i.e. we noticed that the activity in the first iteration dropped a few weeks after the introduction of the new learning system. We also realized that some students engaged in previous weeks' ELs or SLs weeks

after the activities were first introduced. This implies that the gamification design that was using the competitive nature (through deadlines) of the learner was not the only determinant of overall engagement (Harviainen, Lainema, & Saarinen, 2014). The self-paced design of the system where learning activities can be taken anytime may also facilitate flexibility and autonomy in learning, and it seems to have encouraged in our case engagement and deeper learning (L & M., 2012). This was a salient aspect of our gamified online learning system and a contributor to its success as it became very popular among mature students and students in part-time employment (authors' reference).

In summary, our two-year gamification project provided empirical evidence in support of the use of gamified learning systems within a virtual learning environment. Our iterative design did improve the gamified system in the second year and enabled higher levels of student engagement, overcoming the novelty effect. The increase in learning engagement and performance across both years of the gamified intervention indicates that there was significant success vis-à-vis the non-gamified version of the module and the results of an unrelated yet highly engaging non-gamified business module. The noted improvements between the first and the second year of the gamified system indicated that the main issue resolved was the novelty effect. However, they were not statistically significant as it appears that the first iteration was well-designed and achieved high levels of engagement and performance, even though not consistently sustained, with the second iteration only achieving marginal gains and eliminating the novelty effect.

6. Conclusion

In conclusion, the computer-based gamified learning system took learners on board and enabled their learning. Importantly, the gamification elements alone did not sustain engagement although they helped with the discovery and on-boarding of the students. That lack of sustained engagement is often dubbed as the novelty effect and our system was able to overcome it, especially in its second iteration. The emphasis on a coherent narrative and the design of an online gamified learning system with embedded pedagogical elements such as the careful selection and usefulness of learning tasks, clearer expectations, regular communication and feedback enabled the students to learn, leading to high and sustained levels of engagement. The emphasis on a coherent narrative enabled students to take a learning journey that moved them beyond the gamification aspect of the system and thus

progressed them from a state of extrinsic motivation to more intrinsic-like states of being. Our study demonstrates that these pedagogical factors are in line with ingredients of "meaningful gamification."

Thus designers of gamified systems and VLEs should implement such context-specific practices that reduce the impact of the novelty effect that gamification may have on learners by making the system pedagogically relevant to the audience it addresses It is not the technology that is the limiting factor in computer-based gamified systems, it is often the relevance of the content and the manner that this content is delivered. There are clear indications that having a clear communication strategy in delivering that coherent narrative has an important impact on the users and thus on the success of the learning system.

There is a limitation in our study: we gamified the computer-based learning aspects of the module and did not consider the offline aspects of the module. Thus, our assessment of student engagement may be incomplete. A possible solution to this limitation may be incorporating the offline learning into the narrative of a competition and recording the activities and performance onto the system to achieve a fuller picture of student engagement.

7. References

Adegoke, B., Salako, R., & Ayinde, L. (2013). Impact of attendance on students' academic performance in ICT related courses: Faculty of Engineering, Osun State Polytechnic, Iree. *Journal of Education and Practice, 4*(16), 95-98.

Alavi, M., & Leidner, D. E. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS quarterly*, 107-136.

Aluja-Banet, T., Sancho, M.-R., & Vukic, I. (2017). Measuring motivation from the virtual learning environment in secondary education. *Journal of Computational Science*.

Anderson, A., Huttenlocher, D., Kleinberg, J., & Leskovec, J. (2014). *Engaging with massive online courses.* Paper presented at the Proceedings of the 23rd international conference on World wide web.

Anderson, L. W., Krathwohl, D. R., & Bloom, B. S. (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*: Allyn & Bacon.

Baeten, M., Kyndt, E., Struyven, K., & Dochy, F. (2010). Using student-centred learning environments to stimulate deep approaches to learning: Factors encouraging or discouraging their effectiveness. *Educational Research Review, 5*(3), 243-260.

Banfield, J., & Wilkerson, B. (2014). Increasing student intrinsic motivation and self-efficacy through gamification pedagogy. *Contemporary Issues in Education Research (Online), 7*(4), 291-298.

Barab, S., & Squire, K. (2004). Design-based research: Putting a stake in the ground. *The journal of the learning sciences, 13*(1), 1-14.

Barata, G., Gama, S., Jorge, J., & Gonçalves, D. (2013). *Improving participation and learning with gamification.* Paper presented at the Proceedings of the First International Conference on gameful design, research, and applications.

Bartle, R. (1996). Hearts, clubs, diamonds, spades: Players who suit MUDs. *Journal of MUD research, 1*(1), 19.

Blohm, I., & Leimeister, J. M. (2013). Gamification: Design of IT-based enhancing services for motivational support and behavioral change. *Business & Information Systems Engineering, 5*(4), 275-278.

Brickman, P., & Campbell, D. (1971). Hedonic relativism and planning the good society. *Adaptation-level theory*, 287-302.

Cerasoli, C. P., Nicklin, J. M., & Ford, M. T. (2014). Intrinsic motivation and extrinsic incentives jointly predict performance: A 40-year meta-analysis. *Psychological bulletin, 140*(4), 980.

Charles, D., Charles, T., McNeill, M., Bustard, D., & Black, M. (2011). Game‐based feedback for educational multi‐user virtual environments. *British Journal of Educational Technology, 42*(4), 638-654.

Chen, Y. C. (2014). The effect of using a facebook group as a learning management system. *Computers in Education Journal, 5*(4), 42-53.

Clarà, M., & Mauri, T. (2010). Toward a dialectic relation between the results in CSCL: Three critical methodological aspects of content analysis schemes. *International Journal of Computer-Supported Collaborative Learning, 5*(1), 117-136.

Clark, R. E. (1983). Reconsidering research on learning from media. *Review of Educational Research, 53*(4), 445-459.

Conejo, F. (2014). Loyalty 3.0: How to revolutionize customer and employee engagement with big data and gamification. *Journal of consumer marketing*.

Conley, K., & Donaldson, C. (2015). Gamification: The measurement of benefits. In *Gamification in education and business* (pp. 673-688): Springer.

Cruz, L., & Penley, J. (2014). Too cool for school? The effects of gamification in an advanced interdisciplinary course. *Journal of Teaching and Learning with Technology, 3*(2), 1-11.

Davis, K., Sridharan, H., Koepke, L., Singh, S., & Boiko, R. (2018). Learning and engagement in a gamified course: I nvestigating the effects of student characteristics. *Journal of Computer Assisted Learning*.

de-Marcos, L., Garcia-Lopez, E., & Garcia-Cabot, A. (2016). On the effectiveness of game-like and social approaches in learning: Comparing educational gaming, gamification & social networking. *Computers & Education, 95*, 99-113.

Deci, E., & Ryan, R. (1985). The general causality orientations scale: Self-determination in personality. *Journal of Research in Personality, 19*(2), 109-134.

Deci, E. L., & Ryan, R. M. (2002). *Handbook of self-determination research*: University Rochester Press.

Deterding, S. (2015). The lens of intrinsic skill atoms: A method for gameful design. *Humanâ€“Computer Interaction, 30*(3-4), 294-335.

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). *From game design elements to gamefulness: defining gamification.* Paper presented at the Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments.

Dicheva, D., Dichev, C., Agre, G., & Angelova, G. (2015). Gamification in education: A systematic mapping study. *Educational Technology & Society, 18*(3), 1-14.

Dickie, V. A., & Meier, H. (2015). The facebook tutor: Networking education. *Ubiquitous Learning, 8*(2), 1-12.

DomíNguez, A., Saenz-De-Navarrete, J., De-Marcos, L., FernáNdez-Sanz, L., PagéS, C., & MartíNez-HerráIz, J.-J. (2013). Gamifying learning experiences: Practical implications and outcomes. *Computers & Education, 63*, 380-392.

Donnelly, D. F., & Hume, A. (2015). Using collaborative technology to enhance pre-service teachers' pedagogical content knowledge in Science. *Research in Science and Technological Education, 33*(1), 61-87. doi:10.1080/02635143.2014.977782

Erlingsson, C., & Brysiewicz, P. (2017). A hands-on guide to doing content analysis. *African Journal of Emergency Medicine, 7*(3), 93-99.

Fredricks, J. A., Filsecker, M., & Lawson, M. A. (2016). Student engagement, context, and adjustment: Addressing definitional, measurement, and methodological issues. In: Elsevier.

Glover, I. (2013). *Play as you learn: gamification as a technique for motivating learners.* Paper presented at the EdMedia+ Innovate Learning.

Goehle, G. (2013). Gamification and web-based homework. *Primus, 23*(3), 234-246.

Goldin, G. A., Epstein, Y. M., Schorr, R. Y., & Warner, L. B. (2011). Beliefs and engagement structures: Behind the affective dimension of mathematical learning. *ZDM, 43*(4), 547.

Gourlay, L. (2015). 'Student engagement'and the tyranny of participation. *Teaching in Higher Education, 20*(4), 402-411.

Gulliksen, J., Göransson, B., Boivie, I., Blomkvist, S., Persson, J., & Cajander, Å. (2003). Key principles for user-centred systems design. *Behaviour and Information Technology, 22*(6), 397-409.

Guo, P. J., Kim, J., & Rubin, R. (2014). *How video production affects student engagement: An empirical study of MOOC videos.* Paper presented at the Proceedings of the first ACM conference on Learning@ scale conference.

Hamari, J., & Koivisto, J. (2015a). Why do people use gamification services? *International Journal of Information Management, 35*(4), 419-431.

Hamari, J., & Koivisto, J. (2015b). "Working out for likes": An empirical study on social influence in exercise gamification. *Computers in Human Behavior, 50*, 333-347.

Hamari, J., Koivisto, J., & Sarsa, H. (2014). *Does gamification work?--a literature review of empirical studies on gamification.* Paper presented at the 2014 47th Hawaii International Conference on System Sciences.

Hanus, M. D., & Fox, J. (2015). Assessing the effects of gamification in the classroom: A longitudinal study on intrinsic motivation, social comparison, satisfaction, effort, and academic performance. *Computers & Education, 80*, 152-161.

Harviainen, J. T., Lainema, T., & Saarinen, E. (2014). Player-reported impediments to game-based learning. *Transactions of the Digital Games Research Association, 1*(2).

Hassanzadeh, A., Kanaani, F., & Elahi, S. (2012). A model for measuring e-learning systems success in universities. *Expert Systems with Applications, 39*(12), 10959-10966.

Henrie, C. R., Halverson, L. R., & Graham, C. R. (2015). Measuring student engagement in technology-mediated learning: A review. *Computers & Education, 90*, 36-53.

Holmes, N. (2015). Student perceptions of their learning and engagement in response to the use of a continuous e-assessment in an undergraduate module. *Assessment & Evaluation in Higher Education, 40*(1), 1-14.

IBMCorp., I. (2012). IBM SPSS Statistics for Windows, Version 21.0: IBM Corp Armonk, NY.

Koivisto, J., & Hamari, J. (2017). *The rise of motivational information systems: A review of gamification research*. Retrieved from

L, D. E., & M., R. R. (2012). Motivation, personality, and development within embedded social contexts: An overview of self-determination theory. *The Oxford handbook of human motivation*, 85-107.

Landers, R. N., Auer, E. M., Collmus, A. B., & Armstrong, M. B. (2018). Gamification science, its history and future: Definitions and a research agenda. *Simulation & Gaming*, 1046878118774385.

Landers, R. N., & Callan, R. C. (2011). Casual social games as serious games: The psychology of gamification in undergraduate education and employee training. In *Serious games and edutainment applications* (pp. 399-423): Springer.

Leese, M. (2009). Out of class—out of mind? The use of a virtual learning environment to encourage student engagement in out of class activities. *British Journal of Educational Technology, 40*(1), 70-77.

Li, W., Grossman, T., & Fitzmaurice, G. (2012). *GamiCAD: a gamified tutorial system for first time autocad users.* Paper presented at the Proceedings of the 25th annual ACM symposium on User interface software and technology.

Locke, E. A., & Latham, G. P. (1990). *A theory of goal setting & task performance*: Prentice-Hall, Inc.

Lu, O. H., Huang, J. C., Huang, A. Y., & Yang, S. J. (2017). Applying learning analytics for improving students engagement and learning outcomes in an MOOCs enabled collaborative programming course. *Interactive Learning Environments, 25*(2), 220-234.

McKnight, K., O'Malley, K., Ruzic, R., Horsley, M. K., Franey, J. J., & Bassett, K. (2016). Teaching in a digital age: How educators use technology to improve student learning. *Journal of research on technology in education, 48*(3), 194-211.

McLaughlin, C. (2013). Ten years of research shows a move from digital competency to digital fluency. Retrieved from https://www.jisc.ac.uk/blog/ten-years-of-research-shows-a-move-from-digital-competency-to-digital-fluency-08-nov-2013#

Means, B., Toyama, Y., Murphy, R., Bakia, M., & Jones, K. (2009). Evaluation of evidence-based practices in online learning: A meta-analysis and review of online learning studies. *US Department of Education*.

Nicholson, S. (2012). A user-centered theoretical framework for meaningful gamification. *Games+ Learning+ Society, 8*(1), 223-230.

Nicholson, S. (2015). A recipe for meaningful gamification. In *Gamification in education and business* (pp. 1-20): Springer.

Patton, M. Q. (2002). Two decades of developments in qualitative inquiry: A personal, experiential perspective. *Qualitative social work, 1*(3), 261-283.

Petter, S., DeLone, W., & McLean, E. R. (2013). Information systems success: The quest for the independent variables. *Journal of Management Information Systems, 29*(4), 7-62.

Reeve, J. (2012). A self-determination theory perspective on student engagement. In *Handbook of research on student engagement* (pp. 149-172): Springer.

Revere, L., & Kovach, J. V. (2011). Online technologies for engaged learning: A meaningful synthesis for educators. *Quarterly Review of Distance Education, 12*(2), 113.

Robertson, M. (2010). Can't play, won't play [WWW Document]. Hide & Seek. . Retrieved from /http://hideandseek.net/2010/10/06/cant-play-wont-play/S

Rodríguez‐Aflecht, G., Jaakkola, T., Pongsakdi, N., Hannula‐Sormunen, M., Brezovszky, B., & Lehtinen, E. (2018). The development of situational interest during a digital mathematics game. *Journal of Computer Assisted Learning, 34*(3), 259-268.

Ryan, R. M., & Connell, J. P. (1989). Perceived locus of causality and internalization: Examining reasons for acting in two domains. *Journal of Personality and Social Psychology, 57*(5), 749.

Seaborn, K., & Fels, D. I. (2015). Gamification in theory and action: A survey. *International Journal of Human-Computer Studies, 74*, 14-31.

Seery, M. K. (2015). Flipped learning in higher education chemistry: emerging trends and potential directions. *Chemistry Education Research and Practice, 16*(4), 758-768.

Soilemetzidis, I., Bennett, P., Buckley, A., Hillman, N., & Stoakes, G. (2014). *The HEPI–HEA Student Academic Experience Survey 2014*. Retrieved from York:

Uerz, D., Volman, M., & Kral, M. (2018). Teacher educators' competences in fostering student teachers' proficiency in teaching and learning with technology: An overview of relevant research literature. *Teaching and Teacher Education, 70*, 12-23.

van Roy, R., & Zaman, B. (2015). *Moving beyond the effectiveness of gamification.* Paper presented at the Gamification Workshop, CHI.

Wood, L. C., & Reiners, T. (2012). *Gamification in logistics and supply chain education: Extending active learning.* Paper presented at the IADIS International Conference on Internet Technologies & Society, Perth, Australia.

Zichermann, G., & Cunningham, C. (2011). *Gamification by design: Implementing game mechanics in web and mobile apps*: " O'Reilly Media, Inc.".

What is currently known about educational gamification:

- Educational gamification has positive leaning, but mixed results in student learning outcomes.
- Educational gamified system design is critiqued for limited formative research, lack of prototyping, and underexplored user characteristics.
- While gamified elements attract users on board, once the novelty effect wears off user engagement falls.

What this paper adds:

- A gamified VLE was developed to address several system design critiques.
- Evaluation of the longitudinal data indicates significant improvements on student engagement and performance and elimination of the novelty effect in computer-assisted learning systems
- A shift from learner extrinsic to intrinsic motivation linked to gamification and pedagogical factors enabled the overcoming of the novelty effect

Implications for practice and/or policy:

- Coherent, meaningful gamification can successfully drive sustained student engagement in VLEs and can help overcome the novelty effect
- How engagement is measured affects the understanding of the effectiveness of computer-assisted learning
- Gamification and pedagogical factors need to be used in tandem for an engaged, sustained student learning journey that goes beyond the novelty effect

Table 1.

Critiques and improvement implications on the gamified module design.

Critique on the gamification design	Improvement implications
Lacking guidance in game design pattern choice (Deterding, 2015; Nicholson, 2015; Robertson, 2010)	• Diversify design choices to suit different types of learners • Make the "game" narrative clearer
No iterative prototyping (Deterding, 2015)	• Ask students for voluntary feedback regarding module contents • Identify most popular learning activities based on the first iteration and promoted them in the second iteration • Remove learning activities that are not perceived useful (less engaged) • Regular communication with students
Little formative research & understanding of users (Deterding, 2015; Nicholson, 2015)	• Longitudinal study • Collect user information (demographics, learning motivation) • Ask user for voluntary feedback regarding system improvement and activity design • Regular communication with students

Table 2.

Student compositions

	Aca Yr.	Number of response	Female (code:0)	Male (code: 1)	International student
Number (%)	15-16	136	70 (51.5%)	66 (48.5%)	39 (29%)
Number (%)	16-17	168	89 (53%)	79 (47%)	43 (26%)

Table 3.
View count based on the learning activity and student number in the gamified modules and the non-gamified modules

Module title	Number of learning activity (a)	Number of students (b)	Total view (c)	View count per activity (c/a)	View count per person (c/b)	View count per activity per person (c/a*b)
Non-gamified PPD (2014-15)	37	181	5303	143.32	29.30	0.77
Non-gamified CMC (2015-16)	36	175	7377	204.92	42.89	1.19
Gamified PPD (2015-16)	87	165	25295	290.75	153.30	1.76
Gamified PPD (2016-17)	139	168	49042	352.82	291.92	2.10

Table 4.

Descriptive statistics for result engagement in 2015-16 and 2016-17

	Mean	Min	Max	SD
2015-16 (*n* = 136)				
No. of EL (14)	8.06	0	14	4.34
No. of SL (37)	9.51	0	34	8.53
No. of EL and SL (51)	17.57	0	48	12.19
2016-17 (*n* = 168)				
No. of EL (16)	12.83	0	16	3.77
No. of SL (56)	16.34	0	52	14.54
No. of EL and SL (72)	29.18	0	68	16.63

Table 5.

Descriptive statistics for assessment types, student performance means and standard deviations

Cohort	Assessment Components	N	Overall Mean	SD
14-15	Portfolio 1 (35%)	175	56.90	13.12
	Portfolio 2 (55%)		58.67	12.07
	Engagement (10%)		64.87	14.54
	Total (100%)		58.67	10.96
15-16	Portfolio 1 (35%)	165	62.06	14.91
	Portfolio 2 (55%)		59.95	17.57
	Engagement (10%)		67.38	18.01
	Total (100%)		61.35	15.01
16-17	Portfolio 1 (45%) + Engagement (5%)	168	59.57	15.29
	Portfolio 2 (45%) + Engagement (5%)		59.23	17.09
	Total (100%)		59.57	14.78

Table 6.

Descriptive statistics for student prior performance and class attendance (n = 110-168).

	Mean	Min	Max	SD
2015-16 (n = 136)				
PPD1 performance[+]	61.52	33	82	11.69
Class attendance	13.54	2	21	4.20
2016-17 (n = 168)				
Accumulated GPA[*]	60.35	0	78.2	9.37
Class attendance	15.4	2	23	4.21

[+] n= 107; [*] n= 110

Table 7
Abstraction of qualitative data towards an SDT motivational affordance

Code	External Regulation
Condensed meaning unit	Students believed that EL engagement help them achieve good grades and receive rewards
Meaning unit	ELs have an impact on my grade For the engagement mark It is essential to engaging marks To get good marks To get better grades Contribute to portfolio grade For Engagement points within the PPD portfolios To maintain my grade To also get a badge to increase my profile

Table 8
Comparison of student process engagement between the gamified and the non-gamified conditions.

	Cohort	N	Mean	SD	Df	*F* value	*p* value
View count per learning activity	Non-gamified PPD (14-15)	37	143.32	103.86			
	Non-gamified CMC (15-16)	36	204.92	170.95			
	Gamified PPD (15-16)	87	290.75	394.37	298	3.74	.012
	Gamified PPD (16-17)	139	352.72	445.61			
View count per learning activity (for an average student)	Non-gamified PPD (14-15)	37	.79	.57			
	Non-gamified CMC (15-16)	36	1.19	.99			
	Gamified PPD (15-16)	87	1.76	2.39	298	4.05	.008
	Gamified PPD (16-17)	139	2.10	2.65			

Table 9.
Summary of regression analysis for variables predicting student performance in 2015-16 (n = 107)

Variable	Model 1	Model 2	Model 3	Model 4
Step 1				
Gender	–.17*	–.08	–.12	–.10
Class attendance	.44***	.37***	.39***	.38***
PPD1 performance	.35***	.28***	.31***	.30***
Step 2				
Number of EL completion		.26**		
Number of SL completion			.24**	
Number of EL+SL completion				.27**
F	25.14***	22.78***	23.08***	18.72***
Adjusted R^2	.406	.451	.455	.460
R^2 change		.05**	.05**	.06**

Note: Standardized coefficients are reported for tested variables. *$p < 0.05$; **$p < 0.01$;***$p < 0.001$.

Table 10.
Summary of regression analysis for variables predicting student performance in 2016-17 (n = 110)

Variable	Model 1	Model 2	Model 3	Model 4
Step 1				
Gender	-.05	.002	-.01	.001
Class attendance	.48***	.36***	.44***	.41***
Accumulated GPA	.33***	.19***	.31**	.28***
Step 2				
Number of EL completion		.45***		
Number of SL completion			.10**	
Number of EL+SL completion				.25***
F	39.31***	54.55***	32.58***	36.28***
Adjusted R^2	.411	.565	.434	.461
R^2 change		.15***	.026**	.05***

Note: Standardized coefficients are reported for tested variables. *$p < 0.05$; **$p < 0.01$;***$p < 0.001$.

Table 11.
Comparison of student performance between the gamified and the non-gamified PPD modules.

Assessment (%)	Cohort	N	Mean	SD	Df	*F* value	*p* value
Final (100%)	14-15	175	58.67	10.96			
	15-16	160	62.69	10.49	496	6.229	.002
	16-17	162	61.51	10.79			

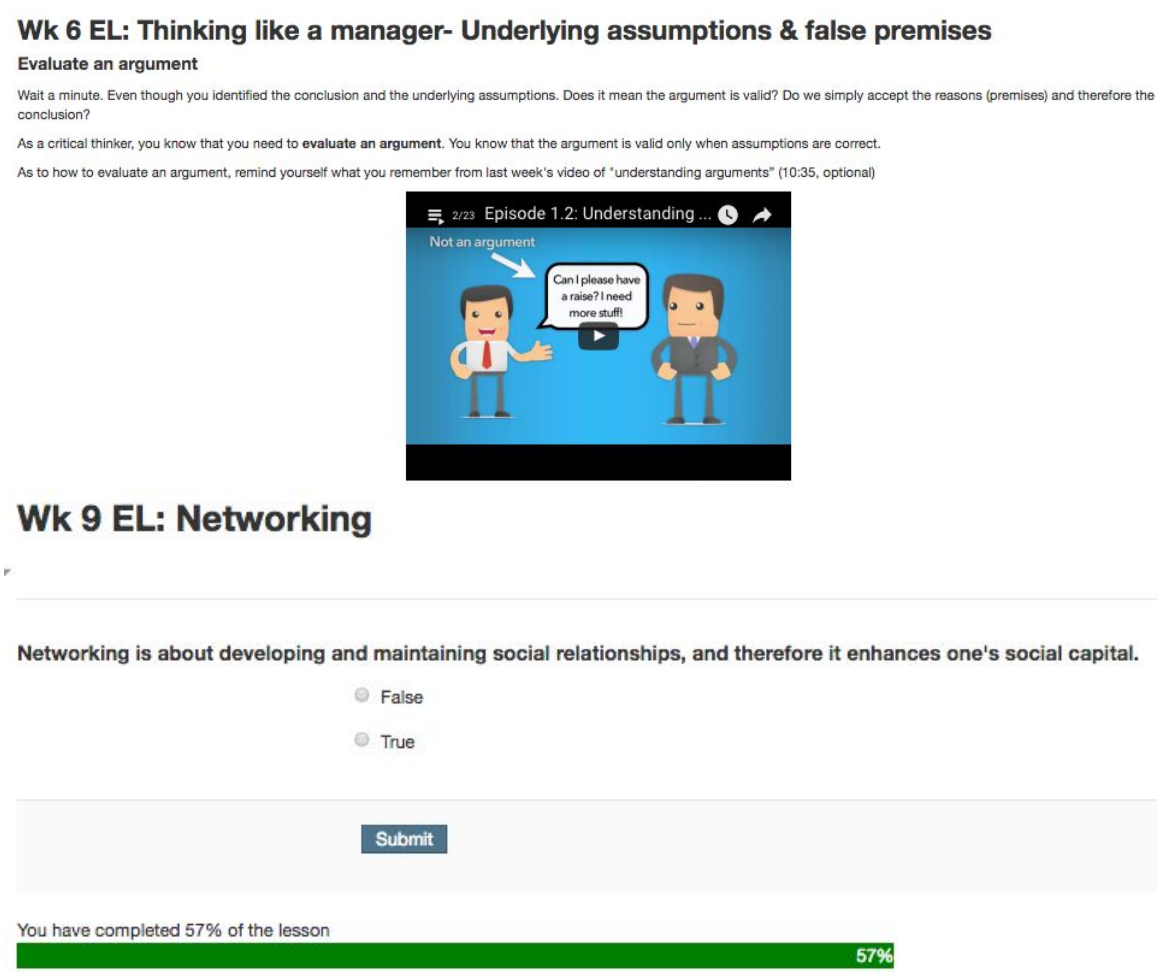

Figure 2. Examples of ELs

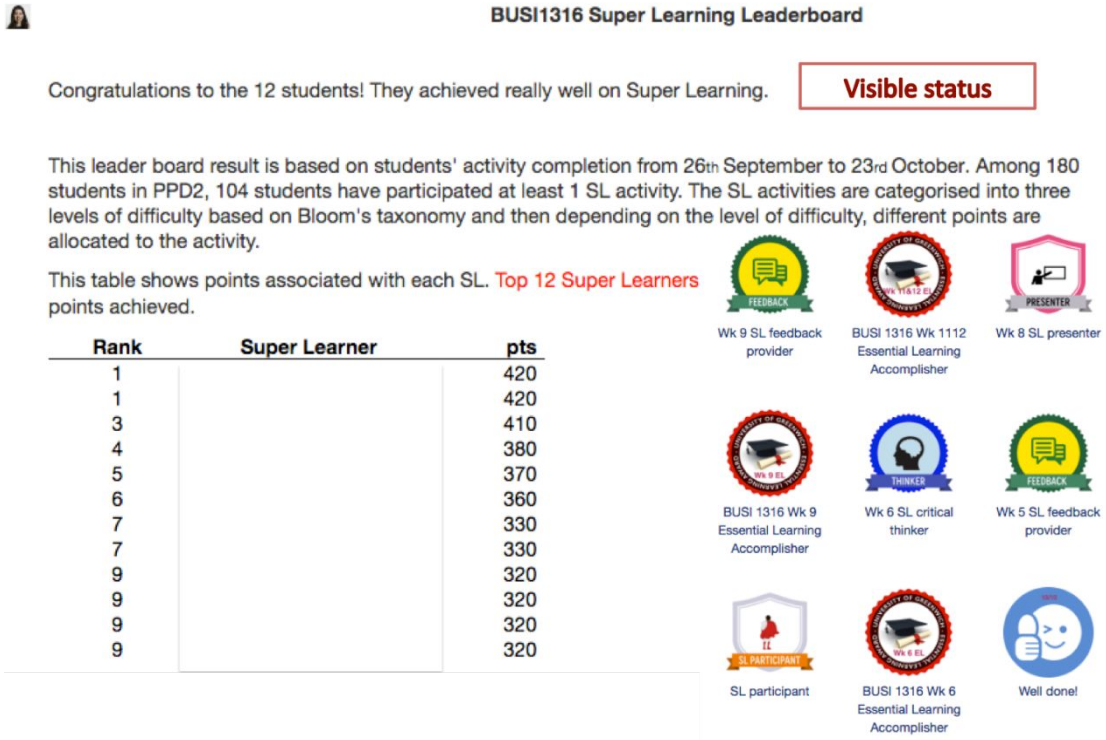

Figure 3. SL leaderboard and badges

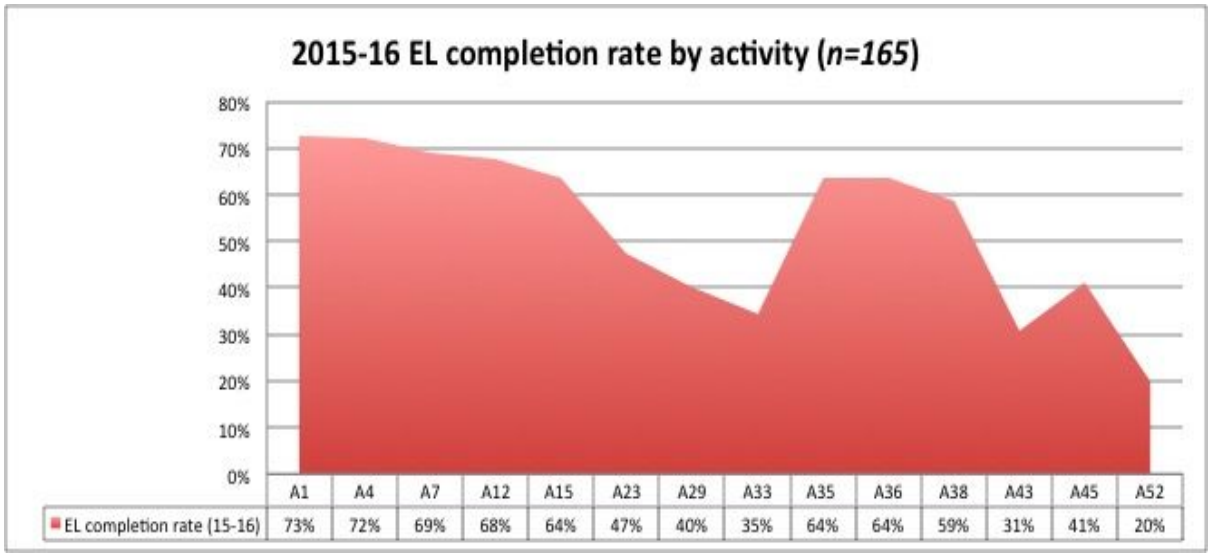

Figure 4. 2015-16 EL completion rate by activity (*n*= 165)

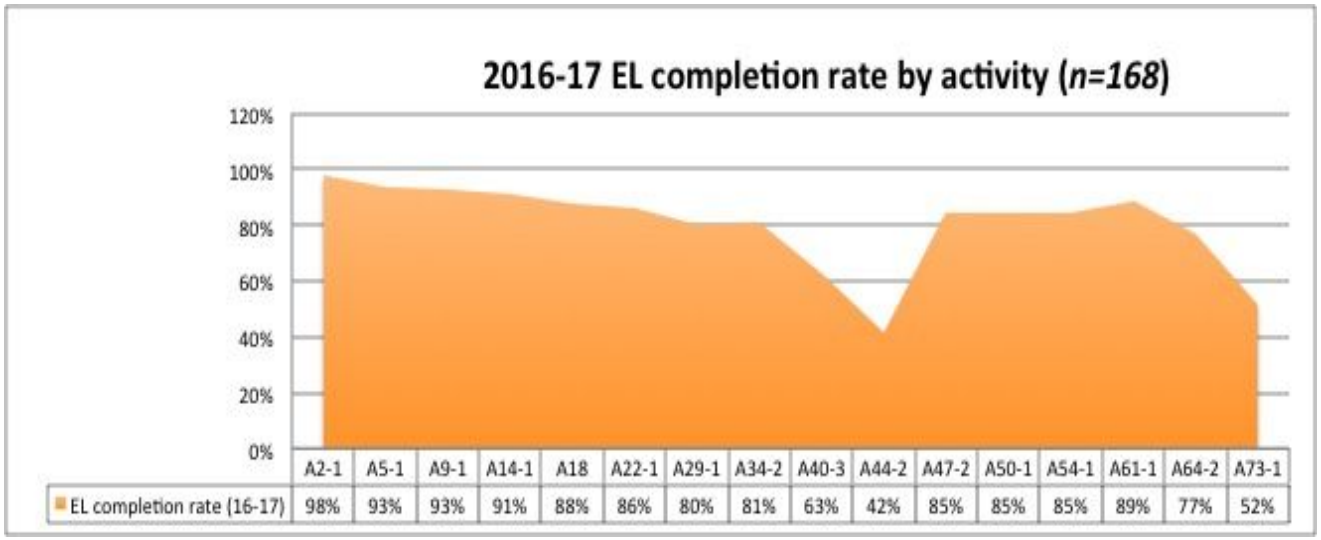

Figure 5. 2016-17 EL completion rate by activity (*n*= 168)

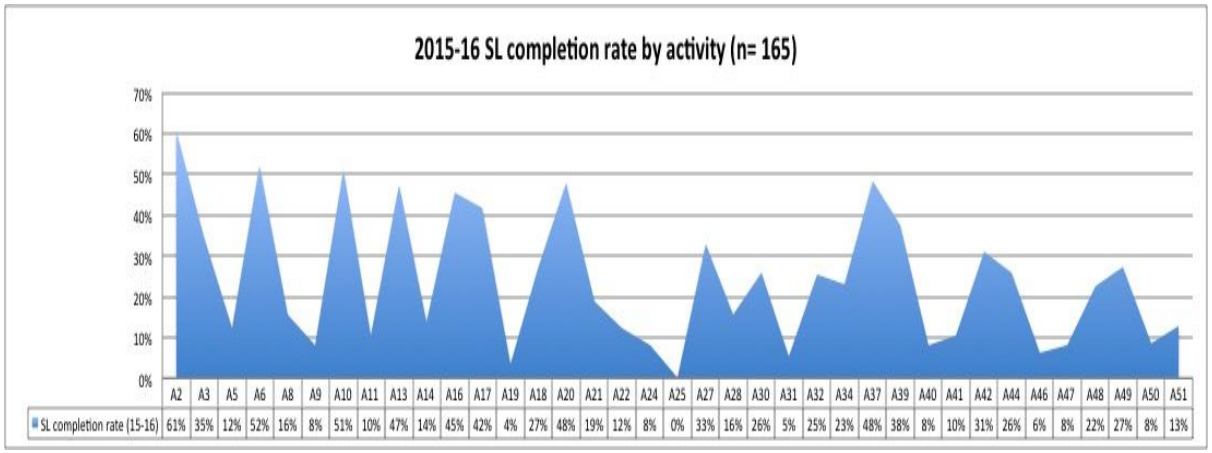

Figure 6. 2015-16 SL completion rate by activity (*n*= 165)

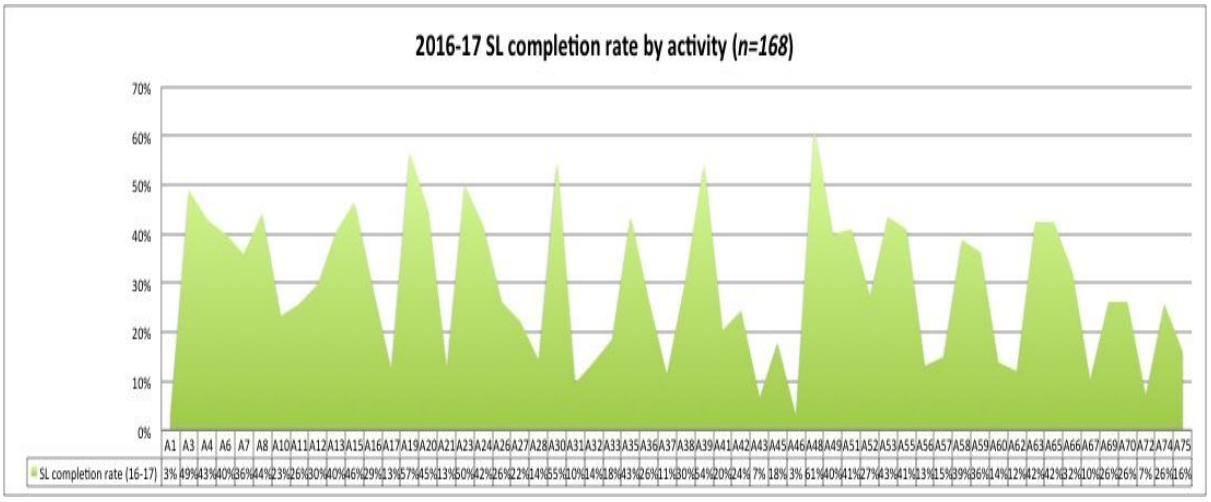

Figure 7. 2016-17 SL completion rate by activity (*n*= 168)

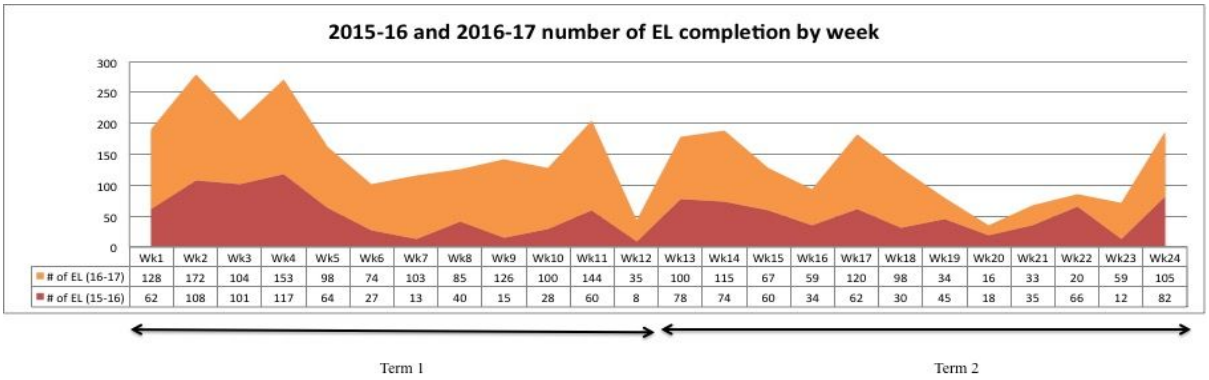

Figure 8. 2015-16 & 2016-17 number of EL completion by week

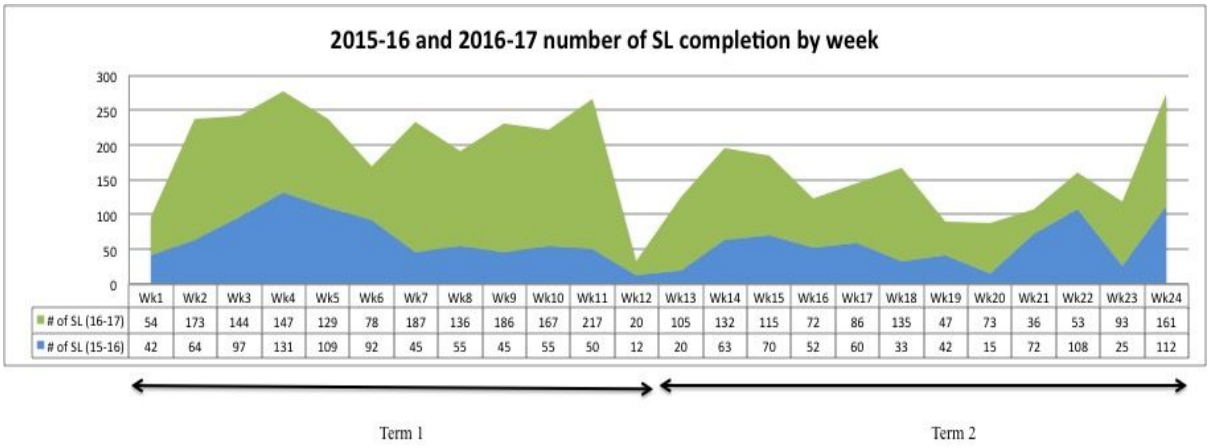

Figure 9. 2015-16 & 2016-17 number of SL completion by week

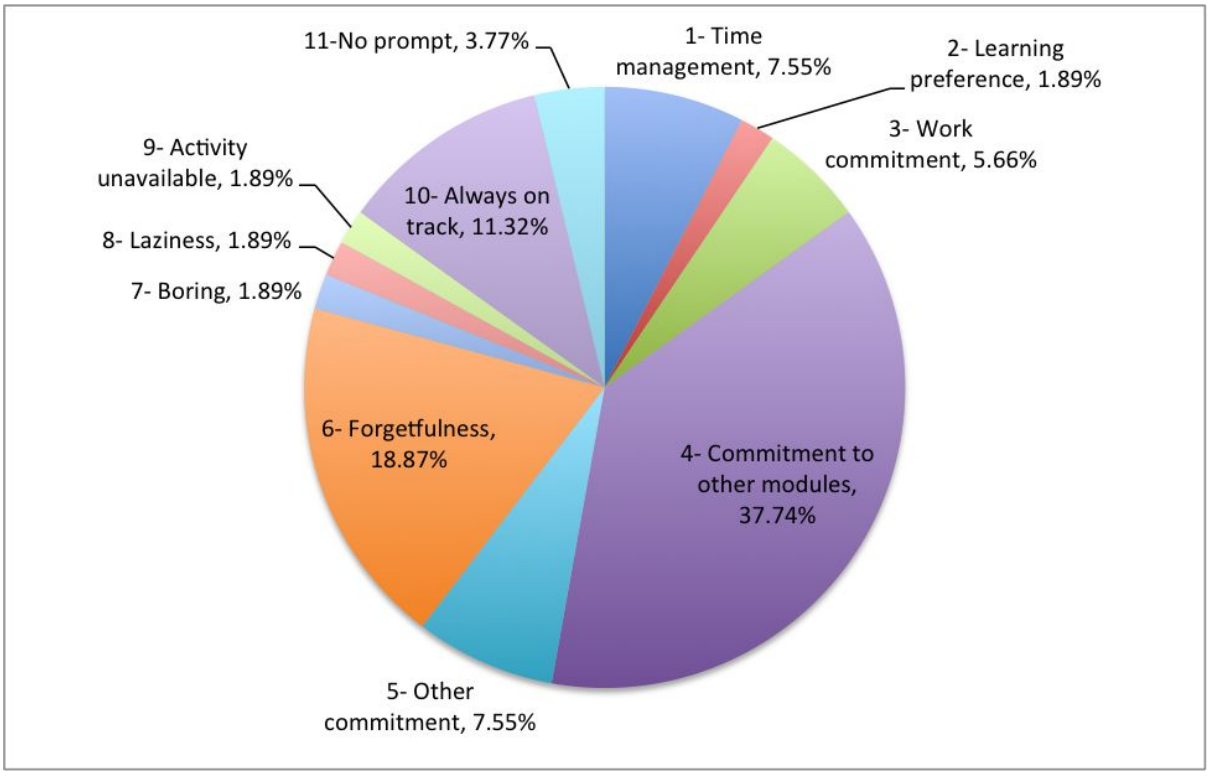

Figure 10. Reasons for non-engagement in ELs

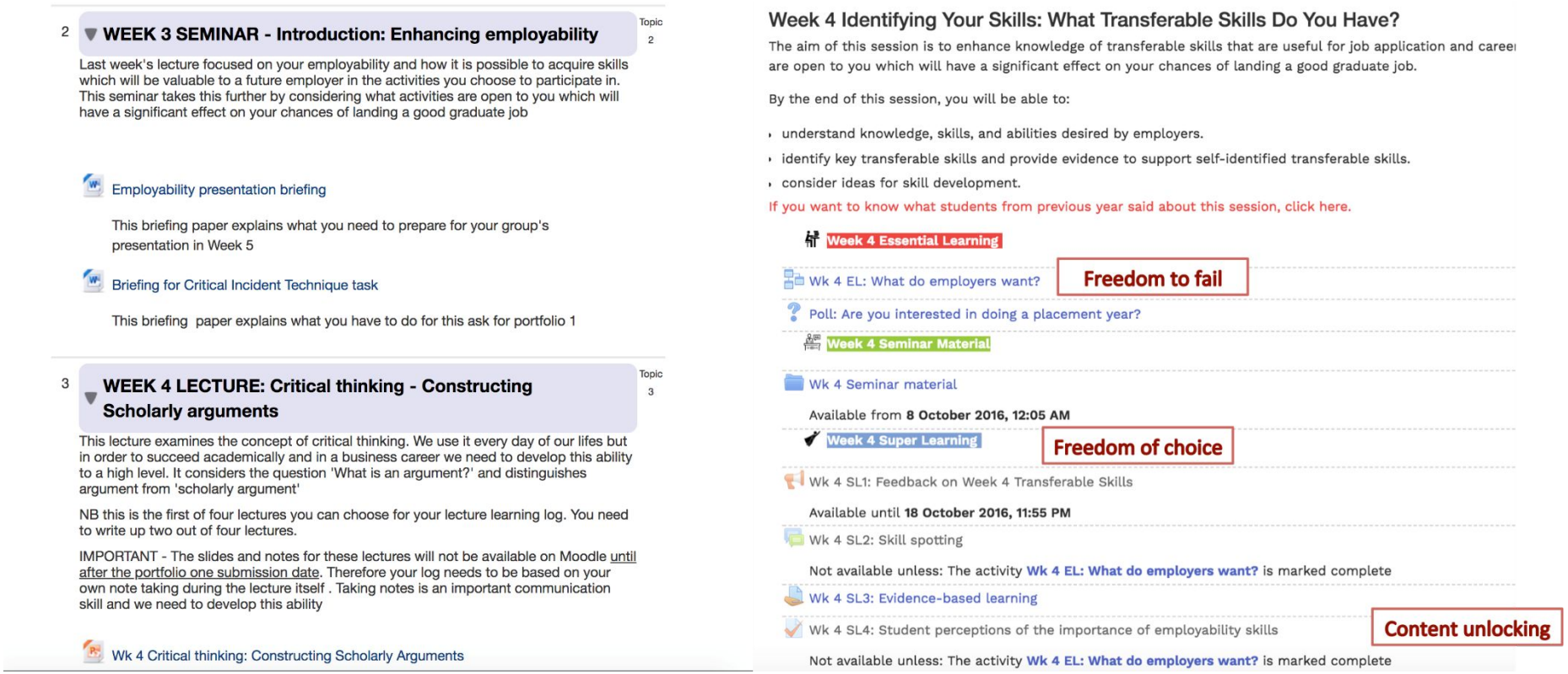

Figure 1. Traditional (left) versus gamified (right) interfaces on Moodle