ARTICLE

Effectiveness of AdventureLEARN, an Online Gamified Platform for Improving Approaches to Learning

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ABSTRACT

The use of gamified tools to increase levels of student engagement has grown in the past decade. The present study examines the effects of a gamified intervention platform, known as AdventureLEARN, on three types of students' approaches to learning: (1) deep, (2) organised, and (3) unreflective approaches. After completing the Approaches to Learning and Studying Inventory (ALSI) on AdventureLEARN, students received a personalised list of learning resources to improve learning approaches, based on their responses on the ALSI. A total of 700 Year One students from Academic Years (AY) 2018 and 2019 participated in this study. Their approaches to learning were measured at the end of Year One. Students who accessed three or more learning resources in AdventureLEARN showed a significant decrease in unreflective approaches to learning after a year, with no significant changes in deep and organised approaches to learning observed. These findings indicate that AdventureLEARN could be a promising gamified platform for reducing students' unreflective approaches to learning. Lastly, the challenge of building a self-driven gamified intervention, rather than a classroom-based intervention, is briefly discussed. The inclusion of additional meaningful gamification techniques that address psychological and social needs are proposed for future research.

The use of gamification, where one employs game elements in a non-game context, has been on the rise in the education sector for the past decade. As students of all ages are familiar with games as an activity for leisure (e.g., video games), teachers have attempted to incorporate the powerful motivational potential of games (de-Marcos et al., 2014) for educational purposes (Bouchrika et al., 2019). By influencing motivation, which can often be lacking in school (Honicke & Broadbent, 2016), students enjoy the subjects taught in class, deepening their engagement to school (Hanus & Fox, 2014). In turn, students attempt to further seek academic information by themselves (Sanchez et al., 2020), managing their learning process without the need for much external influence. As teachers explore the integration of game mechanics in the classroom and design suitable lesson plans to leverage on this new approach, testing of the rationale, application, and measurement of gamification techniques in education still lacks understanding (de-Marcos et al., 2014; Bai et al., 2020). Early results show gamified classrooms effectively enhanced students' study skills and academic performance within the past ten years (Bai et al., 2020). However, some studies have also shown a lack of effect of gamification on motivation and academic performance, or worse, exhibited a negative effect (Hanus & Fox, 2014; de-Marcos et al, 2014).

One area lacking in research is the use of gamified tools to improve study approaches. How students approach studying, referred to as Student Approaches to Learning (SAL), can have a big impact on their academic performance (Asikainen et al., 2014), aside from other more direct factors, such as assignment workload and the availability of school resources (Biggs et al., 2001; Coertjens et al., 2016). SAL could potentially be affected by gamified classrooms should students aim to increase their competency in a subject by applying critical thinking or consuming more complex learning material. Verešová and Foglová (2018), for example, have worked towards discovering the link between motivational constructs, such as self-efficacy, and SAL. Our current study works toward using the motivational power of gamification to change SAL by implementing an online gamified intervention platform, named AdventureLEARN, in a Singapore-based university.

LITERATURE REVIEW

Student approaches to learning

Student Approaches to Learning (SAL) remains a crucial bridging point between an individual's cognitive pattern and their academic performance. What students want from studying could become the deciding factor that affects their grades given similar cognition and mental processes (Biggs, 1987). According to Biggs (1987), there are two different types of SAL: (1) a surface approach, and (2) a deep approach. A surface approach is instrumental in purpose—a student wanting to pass graded assignments, for example. This can be achieved by studying the bare minimum, rote learning and memorisation (Biggs et al., 2001). The surface approach is more recently referred to as an "unreflective approach", to describe such an approach to learning in more neutral terms (Lindblom-Ylänne et al., 2019). For the ensuing sections of this paper, we have used the term, "unreflective approach" throughout. On the other hand, a deep approach seeks to actualise interest and competence via intrinsic influence, such as to gain a more holistic understanding of a specific academic subject. This may be achieved by reading widely and attempting to relate novel information with existing knowledge (Everaert et al., 2017). A deep approach to learning is emphasised in higher education (Lindblom-Ylänne et al., 2019).

SAL allows students to become aware and take control of their study motives and strategy (Biggs, 1985; Jackson, 2004). A student's self-reflection process aids in the comprehension and regulation of the different approaches to learning, allowing them to better prepare for future academic objectives (Verešová & Foglová, 2018). Despite having knowledge of deep approach techniques, a student might choose to revert to an unreflective approach as and when they deem fit (Akçapınar et al., 2020). It is not uncommon for students to use mixed learning approaches within and across semesters (Colthorpe et al., 2018), due to the variances in workload and expectations from teaching staff. For example, a student may use an unreflective learning

approach for a module that tests memory while a deeper approach could be used for another module that assesses critical thinking (Biggs et al., 2001; Biggs, 1987). Similarly, if a semester has a heavy workload but low-effort assessments (e.g., multiple-choice questions, or MCQs), an unreflective learning approach could be utilised to minimise burnout or prevent cognitive overload.

It is important to note that the unreflective and deep approaches to learning are not opposite constructs (Lindblom-Ylänne et al., 2019). In other words, a student reporting high levels in unreflective learning need not necessarily be attaining low levels in deep learning. Lindblom-Ylänne et al. (2019) discovered various profiles of students who displayed varying levels of both unreflective and deep learning, depending on the study patterns exhibited. To categorise an individual as falling into either the unreflective or deep approach unnecessarily simplifies their study behaviour.

Current higher education trends see students adopting a deeper approach as they move on to their second and third year of undergraduate studies (McDonald et al., 2017; Coertjens et al., 2013). This does not occur naturally, instead, the mode of assessment, teaching style, and course structure play a big role in moving students away from an unreflective approach (Coertjens et al., 2016). Unfortunately, it is becoming more common for students to find themselves adopting predominantly unreflective approaches when met with heavier workloads. A well-designed course would not only ideally allow students to be more interested and invested in the educational material, but also space out exam and assessment deadlines to ensure students are not overburdened.

Studies examining the impact or effect of SAL on academic results do not always align (Everaert et al., 2017). Most research on this topic support deep learning approaches having a positive, and unreflective approaches a negative relation with school performance (Asikainen et al., 2014). At the same time, an unreflective approach and study success can be positively related, while a deeper approach can have no relation to scoring well in university. Everaert et al. (2017) even summarised some instances of studies that show a deeper learning approach being linked to less successful academic results. A large portion of these contradictory results can be explained by the existence of a third approach to learning—the organised approach. As Parpala et al. (2010) describes, this approach refers to how organised students are in their study methods and time management. Their study discovered that academic performance may be more dependent on an organised approach to learning compared to a deep approach. According to Asikainen et al. (2014), deep approaches to learning may even be harmful to a student's grades if organised approaches to learning and study techniques are absent (Lindblom-Ylänne et al., 2019). Out of the combination of all three approaches, the best academic performance results from a combination of both deep and organised approaches (Asikainen et al., 2014).

Gamification of education

Gamification is the application of game mechanics, dynamics, and frameworks in a non-game context to promote desired behaviours (Lee & Hammer, 2011). At a time when many students and even teachers are familiar with games, the process of teaching and learning becomes more fun. Gamification uses game mechanics to engage students, motivating them to learn (Sailer et al., 2017), and fosters academic goal-directed behaviour. Several behaviours have been directly targeted and reinforced by gamified learning thus far, such as improving class attendance and participation, changing learning processes, promoting interaction with peers, and assessment training (Subhash & Cudney, 2018). Motivation, including student motivation, is a subject that has been heavily researched (Ryan & Deci, 2000), especially since it leads to concrete and observable school-based output. However, the effect of gamification on behaviour motivation is less understood (Díaz-Ramírez, 2020).

Learning engagement seems to be one motivator to change students' approach to learning. As such, gamified education directly targets engagement to shift how a student interprets their academic task, leading to altered behaviour (Bouchrika et al., 2019; Zainuddin et al., 2020). By deepening engagement, students enjoyably look

forward to and prepare for the next task, developing persistence and deep learning (Lee & Hammer, 2011). Research, however, also cautions against an overbearing application of gamification. Like any motivational tool, an excessive use of gamification has diminishing returns (Sanchezet al., 2020; Welbers et al., 2019). The primary appeal of gamification being a fun mechanic introduced into classrooms may be a novelty effect that wears off over time. Instead, gamification can be used as a starter device to kickstart motivation and engagement before switching over to more diverse educational techniques. Gamification in education is certainly not an alternative to a poorly designed lesson plan (Lee & Hammer, 2011).

Numerous studies indicate a positive relationship between gamification and academic performance (Sanchez et al., 2020; Díaz-Ramírez, 2020). Psychological effects such as addressing competency needs and social relatedness (Sailer et al., 2017), enthusiasm and goal setting (Bai et al., 2020), as well as engagement and motivation (Subhash & Cudney, 2018) are also fostered by the gamification of education. Nevertheless, research on the negative impact of gamification on academic performance does exist, where gamified education decreased intrinsic motivation and final exam scores (Hanus & Fox, 2014), or reduced activity participation and assignment scores (de-Marcos et al, 2014). Such counter-productive results suggest that there needs to be more understanding in the design and implementation of gamification. Given the nascent stage of gamification, not much is known about its application in various contexts.

Gamification proposes several mechanics that aim to effect behavioural changes or satisfy psychological needs. The most basic are PBLs—Points, Badges and Leaderboards (Díaz-Ramírez, 2020)—which have been widely known to affect students' learning behaviours (Sailer et al., 2017; Tan & Hew, 2016; Zainuddin et al., 2020). Other gamified mechanics utilised in student learning, like progress bars, avatars, a levelling system, meaningful stories, and teammates (Sailer et al., 2017; Tan & Hew, 2016) have been applied in past interventions, but require further research (Zainuddin et al., 2020).

With the emerging field of gamification studies in education, research on the effect of gamified interventions on SAL remain unclear. As such, this paper addresses this gap in research by examining the changes in student approaches to learning as a result of using an online gamification intervention platform. More specifically, we evaluated whether our newly designed online gamification platform could successfully increase organised and deep learning, while decreasing unreflective learning. Given the lack of prior studies, our paper will therefore focus on these research questions:

1) Do students who have used AdventureLEARN exhibit lower unreflective approach to learning scores as compared to students who did not, as measured by the Approaches to Learning and Studying Inventory (ALSI; Entwistle & McCune, 2004)?

2) Do students who have used AdventureLEARN exhibit higher deep and organised approaches to learning scores as compared to students who did not, as measured by the ALSI?

Our hypotheses are as follows:

H1: We expect students who have used AdventureLEARN to score lower in unreflective approach to learning than students who did not.

H2: We expect students who have used AdventureLEARN to score higher in deep and organised approaches to learning than students who did not.

METHODS

Current literature suggests that certain approaches to learning (e.g., high unreflective and low deep and organised) lead to poorer academic outcomes. Therefore, a gamified intervention was designed to promote an organised and deeper approach to learning with the long-term aim of increasing academic performance. This intervention, a web-based platform known as AdventureLEARN, took the form of an online micro-learning website where students could complete SAL-related tasks. AdventureLEARN served two aims: first, to increase students' awareness of their default approaches to learning, and second, to help them gain knowledge on how to use more effective approaches (i.e., deep, and organised). After one year of using AdventureLEARN, changes with regards to unreflective, deep and organised approaches to learning were measured. As this gamified intervention platform was designed as a pilot programme, it was optional to use and students' usage did not have any bearing on their grades. This study was approved by the Singapore Institute of Technology's (SIT) Institutional Review Board (IRB, No. 20170053).

Gamified tool: AdventureLEARN

When students log in, they can see an island (Figure 1) comprising four quadrants: 'Promotion of Well-being', 'Grit and Resilience', 'Mindset' and 'Approaches to Learning and Studying'. Students have the choice to start learning any of the four topics from the island, depending on their preference or learning needs. For the purposes of this paper, only results from the Approaches to Learning and Studying quadrant is discussed. Students can enter the platform at any time, using either a computer or smartphone. This enabled on-demand access to the platform, providing more flexibility by allowing the students access as and when they require. The platform was made available to all Year One students, accessible through a hyperlink emailed to them.

Figure 1. AdventureLEARN's main menu.

When students first entered the website (see Figure 1), they were prompted to complete a validated questionnaire (ALSI) that assessed their SAL traits (see Figure 2 for an example of a questionnaire item). Based on the results, the platform algorithm directed students to a personalised list of recommended learning resources to gain further knowledge.

Figure 2. The SAL questionnaire.

Using the drop-down menu on the top left or by clicking on one of the four quadrants of the island (see Figure 1), students could access content related to that quadrant. After viewing each learning resource, students were directed to a quiz that immediately tested their increased knowledge on the topic learnt. This also ensured that rewards were provided specifically to students who have completed the learning resource.

For SAL specifically, these learning resources were short lessons that introduced approaches to learning to the student (see Figure 3), as well as behavioural and cognitive techniques that they could incorporate into their daily routines at their own pace. There are over 100 curated resources (ranging from effective approaches to learning, mindset, well-being, and resilience) which have all gone through a rigorous process of inter-rater reliability for quality and appropriateness. Assessments, developed by academic faculty and staff with psychology backgrounds, evaluate whether students have understood the learning content.

Figure 3. Examples of learning resources.

Users of AdventureLEARN received a personalised list of learning resources based on their responses on the ALSI. For example, students who scored low on "Organised Approaches" may receive recommendations for resources on techniques such as time management and effective note-taking. This feature enabled time-poor students to be referred to materials relevant to their profile, rather than a generic list of learning resources.

AdventureLEARN also addressed the issue of students' levels of motivation by targeting both intrinsic and extrinsic motivation, encouraging students to have a variety of engagement avenues with the intervention platform. The island (see Figure 1) was a visual game mechanic introduced to promote meaningful gamification through increased levels of intrinsic motivation (Nicholson, 2015; Tan & Hew, 2016). As students continually involve themselves with the learning resources offered, the island grows and develops in response. In essence, the island that students first see after logging in is a progress bar that tracks their growth. For extrinsic motivation, tangible rewards were offered in the form of vouchers (see Figure 4) that were redeemable after collecting enough AdventureLEARN coins. AdventureLEARN coins were earne d when viewing learning resources and completing time-sensitive questionnaires.
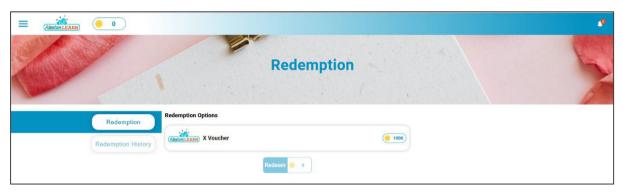

Figure 4. Redeemable vouchers for students when they have collected enough AdventureLEARN coins.

Measurement tool

The three-factor ALSI (Entwistle & McCune, 2004), based on 12 items in the University of Helsinki's HowULearn questionnaire (Parpala & Lindblom-Ylänne, 2012), was used to detect changes in students' approaches to learning (see Appendix). All responses were on a 5-point Likert scale, ranging from "1 = Strongly Disagree" to "5 = Strongly Agree". ALSI has been validated in the European and UK educational environments (e.g., Haarala-Muhonen et al., 2017; Mattick et al., 2004), as well as in Asian contexts (e.g., Ullah & Yasmeen, 2014).

For this study, the survey was validated for the local population via exploratory factor analysis. ALSI results were collected from SIT students as part of a freshmen survey conducted at the start of AY2019 for 762 first-year students. This data was tested with Bartlett's test of sphericity and Kaiser-Meyer-Olkin measure of sampling adequacy. Bartlett's test of sphericity was significant ($p < .05$) and the Kaiser-Meyer-Olkin measure of sampling adequacy was .79 (> .7), which showed that the data was suitable for factor analysis. Overall internal consistency of the ALSI was good, with Cronbach's alpha of .75.

Table 1

Factor loading and communalities

(Item number) Sub-scale	Factor1	Factor2	Factor3	h2
(1) Unreflective	.79	.01	−.02	.62
(2) Organised	−.05	.57	.09	.38
(3) Unreflective	.76	−.03	.04	.59
(4) Organised	.03	.72	.00	.52
(5) Deep	−.07	.05	.59	.37
(6) Deep	−.02	.01	.63	.40
(7) Unreflective	.82	.01	.02	.67
(8) Organised	.01	.84	−.04	.68
(9) Unreflective	.55	.04	−.10	.31
(10) Organised	−.01	.74	.03	.56
(11) Deep	.03	−.03	.80	.62
(12) Deep	.02	.02	.76	.59
% of total variance explained		53%		

Table 1 shows the factor loadings and item communalities. Each factor had significant factor loadings of at least .40 on one distinct sub-scale, and all items were loaded by only one of the factors. Communalities were significant, except for one item from each sub-scale which had values marginally below .40. This indicated that the items of the ALSI scale were relevant and those from the same sub-scale shared a common factor. The three-factor model explained 53% of the variance in the data. The exploratory factor analysis hence verified that the ALSI had a similar factor structure to those found in previous studies, supporting its usage here.

Sample

All freshmen enrolled for AY2018 (AY18) and AY2019 (AY19) in SIT and the SIT-joint undergraduate degree programmes were invited to participate in this study, with participation made optional. Only students who completed both the freshmen and end-of-year surveys were considered for the present analysis.

The AY18 cohort (historical comparison group) completed the ALSI to gain awareness of their approaches to learning but were not introduced to AdventureLEARN. The AY19 cohort completed the ALSI, and were introduced and given access to AdventureLEARN learning materials. For the AY19 cohort, the sample was split into two groups: (1) those that accessed three or more learning materials in AdventureLEARN (AY19 AL) (experimental group), and (2) those that accessed two or fewer learning materials (AY19 No/Low AL) (comparison group).

As this study was conducted university-wide, students ranged across different programmes, including accountancy, engineering, and health sciences (SIT, 2020), providing a level of variance in course type. Table 2 shows the number of survey responses for all groups. For AY18, the number of respondents was 398, for AY19 No/Low AL, it was 221, and for AY19 AL, the number was 81.

Table 2

Survey respondents for the study

	No. of Respondents
AY18	398
AY19 No/Low AL	221
AY19 AL	81
Total	700

Analysis

Data on the ALSI surveys were collected at two timepoints—at the freshmen survey (FMS) conducted during their freshmen orientation, and at the End-Of-Year survey (EOY), administered at the end of the year. The scores on each subscale of the ALSI were aggregated, providing a score for organised, deep, and unreflective approach traits for each student. Scores from the EOY surveys were then compared to the FMS surveys to determine the extent of each student's change in their approaches to learning after one year. As there were three independent groups—AY18, AY19 No/Low AL, and AY19 AL—a one-way analysis of variance (ANOVA) was conducted to examine if these changes were significant.

RESULTS

The descriptive statistics for the learning approaches of all groups are shown in Table 3.

Table 3

Results of all the groups profiled in the study

		N	Mean Change	Std. Dev	Std. Err
Organised Learning	AY 18	398	-.93	2.804	.141
	AY19 No/Low AL	221	-1.00	2.684	.181
	AY19 AL	81	-.64	3.059	.340
	Total	700	-.92	2.796	.106
Deep Learning	AY 18	398	-.42	2.516	.126
	AY19 No/Low AL	221	-.55	2.459	.165
	AY19 AL	81	-.35	2.608	.290
	Total	700	-.45	2.506	.095
Unreflective Learning	AY 18	398	-.11	2.746	.138
	AY19 No/Low AL	221	-.67	3.273	.220
	AY19 AL	81	-1.02	3.768	.419
	Total	700	-.39	3.065	.116

In addition to the data of the three different groups for each of the dependent variables (Organised, Deep and Unreflective learning) having a normal distribution, no significant outliers were detected. Due to the vastly different sample sizes for the AY18, AY19 No/Low AL, and AY19 AL groups, Levene's Test of Homogeneity of Variances was run. The results of Table 4 showed that the assumption of homogeneity was met for two groups—Organised Learning [$F(2, 697) = 1.75$, $p = .18 > .05$], and Deep Learning [$F(2, 697) = .33$, $p = .72 > .05$]—where both p values fell above .05. However, this assumption was not met for Unreflective Learning [$F(2, 697) = 6.56$, $p < .05$]. Welch's ANOVA is recommended when the assumptions of homogeneity are not met (Lix et al., 1996).

Table 4

Levene's Homogeneity of Variances Test

		Levene Statistic	df1	df2	Sig.
Organised Learning	Based on Mean	1.749	2	697	.175
Deep Learning	Based on Mean	.333	2	697	.717
Unreflective Learning	Based on Mean	6.575	2	697	.001

Welch's ANOVA was conducted to compare the effect of AdventureLEARN usage on the three approaches to learning. The one-way ANOVA (see Table 5) showed that the effect of AdventureLEARN usage on Unreflective Learning was significant [$F(2, 197.16) = 3.79, p < .05$]. However, the effect of AdventureLEARN usage on Organised Learning [$F(2, 210.55) = .42, p = .66 > .05$], and Deep Learning [$F(2, 213.37) = .27, p = .77 > .05$], was not significant.

Table 5

Welch's Robust Tests of Equality of Means

	Statistic[a]	df1	df2	Sig.
Organised Learning	.422	2	210.552	.656
Deep Learning	.266	2	213.372	.767
Unreflective Learning	3.794	2	197.161	.024

[a] Asymptotically F distributed.

Following this, a Games-Howell post-hoc comparisons test was conducted to examine the group-to-group differences for Unreflective Learning. As indicated in Table 6, there were no statistically significant difference in Unreflective Learning between the following groups: (1) AY18 and AY19 No/Low AL, (2) AY18 and AY19 AL, and (3) AY19 No/Low AL and AY19 AL. Although uncommon, it is still possible for a pairwise comparisons test (e.g., Games-Howell) to not be significant despite an *F* test (Welch's ANOVA) being significant. This can be attributed to post-hoc tests being more conservative in nature (e.g., Shingala & Rajyaguru, 2015) and should not affect the significance of the Welch's ANOVA.

Table 6

Games-Howell means comparison

	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.
Unreflective Learning	AY18	AY19 No/Low AL	.557	.260	.083
	AY18	AY19 AL	.912	.441	.102
	AY19 No/Low AL	AY19 AL	.355	.473	.734

DISCUSSION

The results show that the pilot intervention, AdventureLEARN, was to some extent effective in impacting students' approaches to learning. The online gamified intervention platform aided students in decreasing their unreflective learning approaches throughout their first year at SIT. AY19 students, who were classified as having used AdventureLEARN, evinced a statistically significant decrease of 1.02 points on average, compared to a statistically non-significant decrease of 0.11 and 0.67 for the AY18 and AY19 NO AL groups, respectively (Table 3). Practically speaking, a decrease of unreflective learning is beneficial considering the high onset of unreflective learning traits displayed by undergraduate students (McDonald et al., 2017; Coertjens et al., 2013). AdventureLEARN could be introduced as a supplementary tool to future freshmen as a way of reducing unreflective learning in their first year at university.

There could be several reasons why AdventureLEARN did not impact all three approaches to learning. Other studies, such as Akçapınar et al. (2020), found that undergraduate students experienced a decrease in organised and deep approaches after entering university. Such drops could be attributed to coping with the heavier university-based timetable and assignments (Biggs et al., 2011). Thus, to cope with the heavier demands, first year students in our study could have similarly adopted fewer organised and deep learning approaches to save time and effort. This has several implications. For example, if students choose to display fewer organised and deep approaches to learning due to high workload/stress, it is possible that they rated themselves accordingly on the ALSI, despite possessing organised and deep learning traits. Since ALSI is a self-assessment, the mixed learning approaches that students might use could have led to our inconclusive results, such as those seen in Colthorpe et al. (2018).

Similarly, as AdventureLEARN was a pilot programme and therefore optional, AY19 students could have perceived AdventureLEARN as unnecessary to their university education. Our gamified intervention platform was not compulsory as a graduation requirement, unlike graded assignments or class attendance. In general, first year SIT students reported high workload and stress as reasons for not utilising more learning resources in AdventureLEARN. Some students might have focused on completing curriculum work over modifying their approaches to learning. This may have led to the low number of users who accessed more than two learning resources.

The AdventureLEARN platform was an experimental project aimed at creating a gamified intervention that could run without the need for a deliberately structured implementation; it did not have to be inserted during class and delivered by faculty, nor was there any new module created to deliver the platform. Students could view AdventureLEARN and learn new techniques for increasing deep and organised learning while decreasing unreflective learning during their personal time. We designed a gamification tool in a naturalistic setting, which sets our study apart from other gamified intervention studies (e.g., Hanus & Fox, 2015; Díaz-Ramírez, 2020) that were carried out under classroom-based conditions. The delivery of gamification in education is not necessitated by human involvement. Many games, gamified applications and websites have managed to modify behaviours despite being administered outside a classroom environment (e.g., Arjoranta et al., 2020).

Expectedly, creating a technologically self-driven platform presented multiple challenges. As Sanchez et al. (2020) and Welbers et al. (2019) espoused, solely using gamification mechanics for an academic intervention could lead to diminishing returns in learning engagement. Eventually the novelty of gamification wears off, and students may likely decrease their interactions with AdventureLEARN unless there are other aspects within the platform that can entice repeated usage. In its current pilot state (beta-testing), AdventureLEARN's features might have been too basic for students, who may have sought additional functions to keep them interested. Functions such as a resource-rating feature, leaderboard, ownership and customisability of an online avatar, and the ability to scale tasks based on the student's competency, are currently being developed for

future iterations of AdventureLEARN. We believe that these functions would increase online traffic into the intervention platform by serving as multiple layers of interactivity.

Likewise, the ability to monitor behavioural change in the application of knowledge is another challenge for a self-driven platform. While AdventureLEARN increased students' awareness of approaches to learning and knowledge on how to use more effective approaches, this may not necessarily lead to different study behaviours. The Knowledge-Attitude-Behaviour (K-A-B) education model posits that information learnt and behavioural change is mediated by affective factors, such as emotions (Marcinkowski & Reid, 2019). Just because students know certain techniques to increase organised and deep approaches to learning does not equate to an emotional attachment to those techniques. This could lead to an inconsistent use of SAL information when studying. Certainly, additional research, in relation to the K-A-B model could uncover the emotional connection between AdventureLEARN usage and modified behaviour for these group of students. Including faculty who guide students on reflecting and applying effective learning techniques, after using AdventureLEARN, may be necessary for more sustained behavioural change.

This study is not without its limitations. Firstly, this study could be considered less experimental in nature as participation was voluntary. The use of a convenient sample may have skewed the results; students who chose to use AdventureLEARN could have possessed different traits (e.g., motivation, stress level) than those that did not. Secondly, as the ALSI is a self-reported instrument, it might be subject to biases in reporting (e.g., social desirability biases), as with all self-reported measures. Thirdly, the results of this study cannot be generalised to all higher education students as data was collected in only one university in Singapore.

CONCLUSION

Overall, our paper was one of the first studies to directly attempt to change student approaches to learning (SAL) using an online gamified intervention platform, AdventureLEARN. By using carefully crafted learning resources, a historical comparison group, and a locally validated measurement tool, it became possible to examine the influence of such an intervention after a period of one year. Unreflective approach to learning was observed to have decreased, on average, for first year SIT undergraduate students, mitigating the presence of high unreflective learning in freshmen and potentially benefiting long-term academic performance. No increase in organised and deep learning traits were observed in this study. As AdventureLEARN was shown to be only partially effective, the platform needs to be further developed in line with some points discussed earlier. In its current state, it can be recommended to new students who may rely on unreflective learning techniques to study university-level subjects. This can also be complemented with academic advisors who conduct follow-up meetings with students on the proper reflection and application of effective learning approaches, for more sustained behavioural change.

For future research, we recommend that a more rigorous experimental design with proper experimental and control groups be used. In this regard, we advocate the use of random sampling for a selection of participants where practically feasible. It may also be necessary to determine the game mechanics, especially when using online intervention, that affect student approaches to learning. There has been much discourse surrounding common mechanics like PBLs—Points, Badges, and Leader boards—and their behavioural and psychological consequences. Building up the effects of AdventureLEARN's mechanics in relation to student approaches to learning can be explored. The inclusion of additional meaningful gamification techniques (Nicholson, 2015; Tan & Hew, 2016), which not only provide extrinsic incentives but also serve psychological needs (Ryan & Deci, 2000), could be one such avenue to study and modify the mechanics described in this paper.

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APPENDIX. **APPROACHES TO LEARNING AND STUDYING INVENTORY (ALSI)**

ABOUT THE CORRESPONDING AUTHOR

LIM Sok Mui is an Associate Professor at the Singapore Institute of Technology (SIT). May is the Director of the Centre for Learning Environment and Assessment Development (CoLEAD) that looks after the faculty development programmes in learning and teaching at the university level. In educational research, she has experience in research projects on experiential learning, learning space, use of gamification in teaching, work-integrated study and cohort study of students' traits and development.

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