Solve Education!

Gamification as a Learning Tool

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Traditional classroom teaching has long been perceived by students as boring and ineffective. With technological advancements enabling more digitised learning environments however, educators contending with this problem of low motivation have sought gamification not only to teach but also to reinforce skills such as problem-solving, communication, and collaboration. Gamification, defined by Deterding et al. (2001), is the "use of game design elements in non-game contexts" (p.9). Wang (2011), further highlights its purpose to "drive behaviours and effect desired outcomes".

How can we bring about outcomes such as greater engagement, motivation, performance and participation? These outcomes are achieved through design elements such as but not limited to: experience points, levels, leaderboards, prizes, challenges, badges, immediate feedback, customisation, storyline, and progress bars. Each educator/'game' creator uses these to varying degrees, and as later discussed there are also negative aspects to design elements when used in certain contexts. This paper is divided into 2 parts; the first analyses the Strengths, Weaknesses, Opportunities and Threats of implementing gamification in the educational context, and the second uses this information to introduce the gamification elements of Dawn of Civilization (the educational-game developed by Solve Education!).

SWOT Analysis

Strengths

The main strengths of gamification is that it is able to induce certain behaviours and results in students; these can be grouped into the following categories: increased engagement, motivation and achievement.

Engagement

Engagement refers to the quantity and quality of interaction between the student and the learning environment. A systematic mapping study conducted by Dicheva et al. (2014) analysing the results of 34 empirical studies on gamification in education reported significantly higher engagement of students in "forums, projects, and other learning activities" (eg Anderson et al. 2014; Akpolat & Slany 2014; Caton & Greenhill 2013).

Focusing on Anderson et al. (2014) specifically, a large-scale badge experiment allowed the authors to see the difference in forum participation for Stanford University machine learning classes offered on Coursera, where a system of badges were (referred to as ML3) and were not (referred to as ML1 and ML2) implemented. Badge design followed the following principles:

- The badges were designed as "milestone badges" and followed the principle that "a suite of several, less-valuable badges targeting the same action" was more effective as a group than a single "super-badge";
- Badges were also distributed in four levels - bronze, silver, gold, and diamond - associated with increasing milestones and corresponding difficulty;
- Actions such as voting and reading would allow students to acquire badges where as posting and commenting did not (p.693).

The effects of these badges are shown in Figure 1 (a, b, c, d):

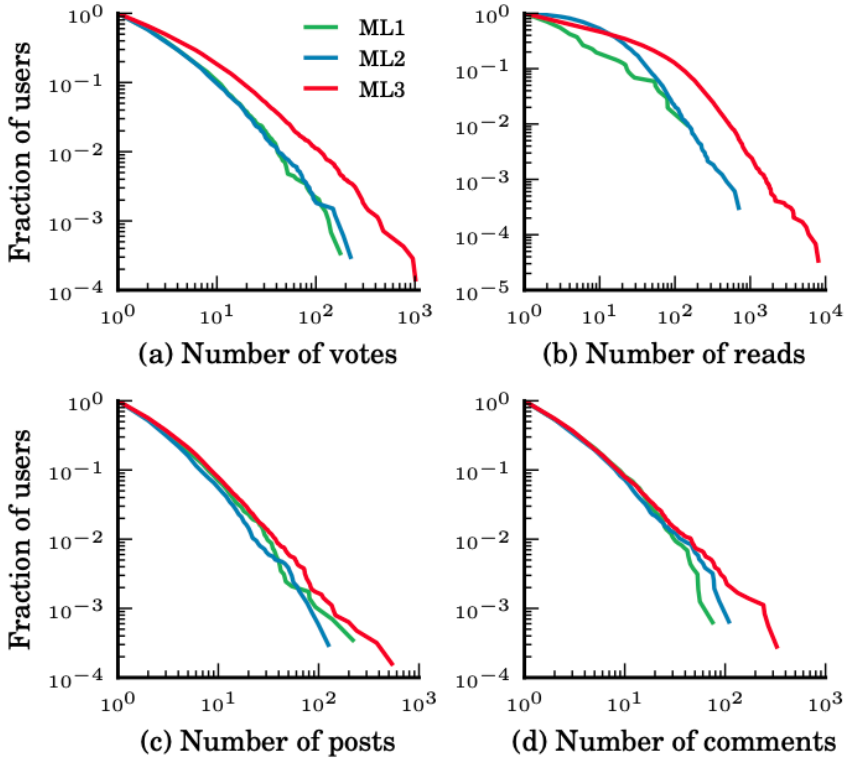


Figure 1(a, b, c, d): Normalised Complementary Cumulative Distribution Functions of Different Actions

Note: This figure is adapted from Proceedings of the 23rd international conference on World wide web - WWW '14 (p.694) by A. Anderson, D. Huttenlocher, J. Kleinberg, J. Leskovec, 2014. ACM Press.

Figure 1(a) shows the complementary cumulative distribution function (CCDF) where the point (x,y) shows that y fraction of users voted at least x times (as a fraction of the total number of users who voted at least once). The normalisation of curves by the total number of students who voted at least once allow for comparison between the different actions. In both 1a and 1b, the distribution in ML3 is more heavy-tailed than in ML1 and ML2, indicating that users were more engaged in voting and reading in ML3 respectively. The forum actions that did not garner badges (such as posting and commenting) had largely similar distributions for ML1, ML2 and ML3, as shown by Figures 1c and 1d. Therefore, actions that did not have cumulative badges did not show significant differences in engagement. Contrastingly, actions with cumulative badges such as voting and reading had much more engaged learners in ML3 than in ML1 and ML2.

Strikingly enough, Anderson et al. (2014) found that it is not only the presence of badges that altered engagement, but the way they were presented too, noting that "making badges more salient produced an aggregate increase in forum activity", and that the strongest effect came from a design that made student progress toward a badge "visible and explicit" (p.689). Social mechanisms such as from "displaying a student's current set of badges next to their names" also affected forum activity.

A study by Paul Denny (2013) of 1031 university students also measured the impact of a badge-based achievement system and discovered "a highly significant positive effect on the quantity of students" contributions, without a corresponding reduction in their quality, as well as on the period of time over which students engaged with the tool" (p.763).

Motivation

Motivation differs from engagement in which it deals with the question of want-to as opposed to have-to - the latter of which many students face in schooling, but not in gaming. The enjoyment that the student derives is important in establishing lifelong learning habits. A literature review by Nah et al. (2014) studied 15 papers with empirical data in which 6 reported increased motivation or enjoyment as a Learner outcome (p.402-403).[1] The summaries of two of them are as follows:

- Brewer et al. (2013) introduced a scoring and prize system into the experimental tasks and task completion rate increased from 73% to 97% with the gamified systems;

- de Freitas & de Freitas (2013) applied gamification elements such as experience points, levels, and in-game rewards to a software called "Classroom Live" in an undergraduate computer science class at the US Air Force Academy. The paper reported increased levels of enjoyment and that despite "Classroom Live" being completely voluntary, 85% of students choose to participate in it as opposed to traditional learning (2013).

[1]The lack of other papers having motivation as a learner outcome does not necessarily mean that the students weren't motivated, but just that perhaps it wasn't a predetermined measured outcome.

Achievement

Achievement refers to the improvement in performance in the following studies, measured by their respective metrics. This section will detail 2 studies in which performance improved with the use of gamification elements.

A Turkish study by Turan et al. (2016) examined the performance of a control group of 48 students (trained traditionally) and an experimental group of 46 students (trained using gamification elements) in a 6th grade IT course about spreadsheets. Over the 6 weeks, gamification strategies such as competition, points collection and group-work were implemented to the 'experimental' group, as well as badges being administered by the online classroom platform 'ClassDojo'. At the beginning and at the end of the 6 weeks, achievement tests were conducted for both groups. The Mann-Whitney U test was used, and in the pre-test analysis, no significant difference in Achievement was seen: U=993, p=0.389 (2016, p.66). However, a significant difference between the experimental and control group was observed in the post-test, which is shown in Figure 2:

	Experimental Group (46)		Control Group (48)			
	Mean Rank	Sum of Ranks	Mean Rank	Sum of Ranks	*U*	*p*
Post-Test Score	58.92	2719.50	36.55	1754.50	578.50	.000

Figure 2: Mann-Whitney U Test Results of Post-Test Scores

Note: This figure is adapted from International Journal of Emerging Technologies in Learning (iJET), 11(07)(p.66) by Z. Turan, Z. Avinc, K. Kara, Y. Goktas, 2016. U=578, p=0.000.

As seen in Figure 2, the academic achievement rate of the experimental group was significantly higher than that of the control group. The experimental group earned better achievement scores. However, there were also negative effects relating to higher cognitive loads that will be discussed in the 'Weaknesses' section.

The next study, conducted by Iosup and Epema (2014) in Delft University of Technology, was a long-running (spanning 3 years) look into the effects of gamification for BSc and MSc Computer courses. It was followed by 450 students, and used the gamification elements as shown in Figure 3:

	BSc-C0	MSc-CC
Course Level	First-year, Bachelors	Masters
Point Systems	Course points, access tokens	
Levels and access	Access to various elements	
Leaderboards	Hall of Fame	
Badges	Various	No
Onboarding	Entry quiz, 5% bonus to final grade	
Social Engagement loops	Teams of 2-4 for Lab	
	Teams of 6 for Self-Study	—
Unlocking content	Unlocking Lab bonus assignments	

Figure 3: Use of Gamification Mechanics in Course Design

Note: This figure is adapted from Proceedings of the 45th ACM technical symposium on Computer science education, The Netherlands (p.30) by A. Iosup & D. H. Epema. 2014.

And the results were summarised as follows:

	Participants (Completed)		Bonuses		
Spring,	In-class	Lab	Self-Study	In-Class	Lab
B'10*	93 (65%)	118 (78%)	——	——	——
B'11	122 (65%)	114 (96%)	——	1.1%	10%
B'12	147 (65%)	130 (95%)	15%	25%	4%
B'13	161 (80%)	118 (97%)	25%	32%	10%
M'13	34 (76%)	26 (92%)	——	88%	59%

Figure 4: Row B'xy (M'xy) has results for BSc-CO (MScCC) in year 20xy.The denotes a course without gamification, used as comparison. Percentages without parentheses are relative to In-class participation (Iosup and Epema, 2014, pp.30)

Note: This figure is adapted from Proceedings of the 45th ACM technical symposium on Computer science education, The Netherlands (p.30) by A. Iosup & D. H. Epema. 2014. *Row B'xy (M'xy) has results for BSc-CO (MScCC) in year 20xy. The denotes a course without gamification, used as comparison. Percentages without parentheses are relative to In-class participation.*

In relation to achievement, the results indicate:

- There is an increased percentage of passing students as indicated by the in-class and Lab completion percentages (in brackets). In 2013, 80% of students passed the in-class course; for previous years, only 65% have completed;

- For class BSc-CO, in-class bonus achievement ("Bonuses, In-class") has increased every year, even though the number of participating students has not changed significantly. The authors have attributed this to the social dynamic that gamification has added to the course, where interaction and competition between students become motivators to return to class. Supporting this further is the increasing number of students who choose to complete the Self-study (done in teams of 6).

Weaknesses

Despite its many strengths, gamification is context-dependent, which means that implementing elements such as points, leaderboards and badges without proper design may not ensure desired outcomes. This paper has identified the following main weaknesses: loss/no change to achievement, undesired behaviour and being a large time/monetary investment.

Loss/no change to achievement

In the systematic mapping study by Toda et al. (2018) of gamification's negative effects, loss of performance was the most reported issue (p.149). This outcome is defined by situations in which gamification hinders students' learning processes. Hanus and Fox (2015) found that while studying gamification through a combination of leaderboards, badges and competition mechanics, those in the gamified group (relative to the control group) were less motivated in class, which was associated with lower grades in the final exam (p.159)[2]. These demotivating effects are further echoed by Barata et al. (2013) and Attali & and Arieli-Attali (2015). Campos et al. (2015) reported that due to a lack of understanding of rules, students' performance was hindered. Snow et al. (2015) reported that "game-based features may act as seductive distractors", with the result that students' use of in-game currency had an "immediate negative impact on in-system performance, daily strategy performance, and learning transfer" (p.423).

The proposed reason for this was that students placed a higher importance on spending their earned resources to interact with new features and therefore spent less time engaged in the learning tasks. Finally, McDaniels et al. (2012) stated that in their "choose-your-own-adventure" game in which the badges you collected were your achievements, some badges designed as "hidden" achievements were too difficult to achieve. This was frustrating to students as part of their grade for the course was based on the number of achievements collected.

[2]Interestingly, Hanus and Fox note that since the course was elective, students joined presumably of their own free will; however, when a reward system is imposed atop a class students already find interesting, "it may feel constraining and forced" (pp. 159). On the other hand, when students perceive a task to be boring, rewards and incentives increase intrinsic motivation - making gamification a 'double-edged sword'.

Undesired behaviour

Another aspect of gamification's weakness would be that undesired behaviour arose. In this paper, it is defined as a different effect (positive or negative) on the learning context either due to bad planning or the lack of it.

Though the Turkish study in the Strengths section and Achievement subsection reported higher achievement due to gamification, the average cognitive load scores of the experimental (gamified) group were higher than those of the control group (Turan et al., 2016). The authors provided 3 possible reasons for this phenomenon:

- The gamified group had to deal with the "necessities of gamification at the same time as completing tasks" (p.67). The work of Sweller et al. (1998) reported that unnecessary elements in instructional designs increase extraneous cognitive load levels, which leads to decreasing germane load (inhibiting the schematic learning process);

- The goal-free effect of cognitive load theory, in which Sweller et al. suggested that goal-free tasks reduce the extraneous cognitive load. Because gamification requires students to constantly pursue goals, this uses their limited memory capacity and taxes their cognitive load levels;

- The social competition aspect of trying to win badges and rewards while completing other activities increased levels of cognitive load and "inhibit focus". Hwang et al. (2013) as cited in Turan (2016), notes the "known high positive correlation between competition anxiety and cognitive load (2013).

Indeed, the last finding regarding competition anxiety in students has been reported by others such as Codish and Ravid (2012) who stated that their game mechanics caused demotivation from excessive competition, Prause and Jarke (2015), and Papadopoulos et al. (2016), who employed similar mechanics. A study by Domínguez et al. (2013). reported that "gamified activities help to develop practical competences.." but "hinder the understanding of underlying theoretical concepts" (p.386). This is argued based on the result that in comparison to the control (non-gamified) group, the experimental group performed better on the practical application of concepts, but worse on the written examination (asked mainly about concepts and their interrelations). This is also identified as a trend by Ke's (2009) meta-analysis, which suggested that learning games are more beneficial in facilitating high-order as compared to factual knowledge.

Time & Monetary Investment

Perhaps the most ubiquitous weakness to gamification for educators would be the time and monetary investment that surpasses traditional teaching. A study by O'Donovan et al. (2013) teaching university-level students heavily emphasised the substantial time and monetary costs, with an extra 6 hours of work per week, and monetary costs of prizes and maintaining quizzes every year. Of course, these investments will vary between different gamification projects, however these trends have been echoed by most educators. Similarly, de Freitas & de Freitas (2013) reported that using gamification in the classroom had increased their course preparation time twofold, but that efforts to streamline instruction were underway. Growing digital enhancements in the education sector will also seek to reduce the instructor's workload, providing great opportunities for enhanced learning in the near future.

Opportunities

Contextualisation

The literature review by Majuri et al. (2018) of 128 gamification papers highlighted the need for future research to understand the contextual factors that may improve the gamification experience and more effectively bring about desired outcomes (p.17). They specifically highlight "demographic (Koivisto & Hamari, 2014) and personality factors, the associations of the task in general and the temporal and spatial context". Furthermore, since humans have different learning styles in addition to personality and demographic characteristics, Majuri et al. have underlined addressing these in instruction design. From the studies surveyed, virtual learning is by far the most commonly applied; educators can seek to employ auditory or kinesthetic learning styles to more effectively cater to a wider range of learners.

Socialisation and Immersion

Currently, most gamification designs are focused on "achievement-oriented mentalities" (Koivisto & Hamari, 2019, p.204). However, research on the motivating factors of games states that the drivers of gamers are much more diverse; while some do play for achievement-gratification, the social aspect of playing with others and the ability to immerse yourself (into stories and roleplay) are also important. Recent developments in virtual reality and reality-augmenting designs (recall the release of Pokemon-Go in 2016) further allow social and immersion-focused affordances to support collaborative action and cooperation.

Feedback

Feedback mechanisms have also been a common lead of further research to make gamification more effective. In particular, it would be useful to identify both effective student behaviour as well as develop methods that "automatically recognise students who require help or are lacking an understanding of a key concept" (Anderson et al., 2014, p.696). In instances where there is a lack of a teacher, this proves eminently useful as students will be able to receive some form of feedback to improve their work. This writer also assumes that improved feedback streams would lessen the achievement gaps of the high-achieving and low achieving students - decreasing the demotivating factor of game elements such as competition.

Threats

A Replacement to Teaching?

Gamification is independent of knowledge or skills; instead, it should work to affect engagement and motivation. In this vein, it is crucial to note the problem that creators try to influence an outcome rather than behaviour through gamification (Huang & Soman, 2013, p.15). To illustrate, one cannot gamify good grades but can gamify the journey to get there.

Huang & Soman (2013) also warn against using gamification as a replacement for a comprehensive curriculum or face-to-face teaching. They warn instructors that depending on extrinsic motivators in the game to modify student behaviour may prove detrimental as "the habit created...may not sustain once the extrinsic reward is gone" (p.16). The importance placed on human teaching is also asserted by Leong & Yanjie (2011), whose results show that game mechanics work best only when teamed with "strong teaching staff who are able to design effective assignments, grade students' work relatively quickly, and interact with students closely" (p.4).

In the field of education, gamification could improve the way people interact with their learning environments and not only make studying more effective, but also much more enjoyable. In the case of a non-profit called Solve Education!, they are also striving to make learning accessible to all students - regardless of socioeconomic background. The following is a brief overview of the gamification elements they have implemented to achieve this mission.

Dawn of Civilization: A Gamification Programme by Solve Education!

Dawn of Civilization is a gamification programme developed by the non-profit Solve Education! in 2017 to provide education for the young people of today (Solve Education!, 2020). It is first and foremost a learning programme (with its flagship curriculum of English) where the students build their own city and try to become the best 'mayor'.

Figure 5: A graphic of the city-building interactive feature in Dawn of Civilization

The instruction design uses the following gamification elements, which seek to induce players' behaviour in different ways:

Minigames

The main method of learning English is through minigames in Dawn of Civilization. At the time of writing, there are 16 minigames which engage the students in not only visual learning but also incorporates auditory learning through the speaking and listening minigames such as 'Tick Talk' or 'Chat Time'.

Figure 6: A selection of the mini-games available in Dawn of Civilization

Leaderboard and Prizes

Every week, players are entitled to win a prize (Rp 50,000 worth of mobile data) if they rank first in a Leaderboard. The more minigames you play, the more friends you get and the more learning tickets you earn, the more likely you are to top the leaderboard. This is a way to keep learners motivated and create a sense of eagerness to advance their names for their accomplishments. In order to avoid demotivation for lower-ranked players, only the first 10 names are displayed. Furthermore, the leaderboards are reset every week, which gives players ample opportunity to improve and try their chances next week. This creates a competitive environment that does not fail from students' social anxieties, mentioned above (section 'Weaknesses', subsection 'Undesired Behaviour').

Points

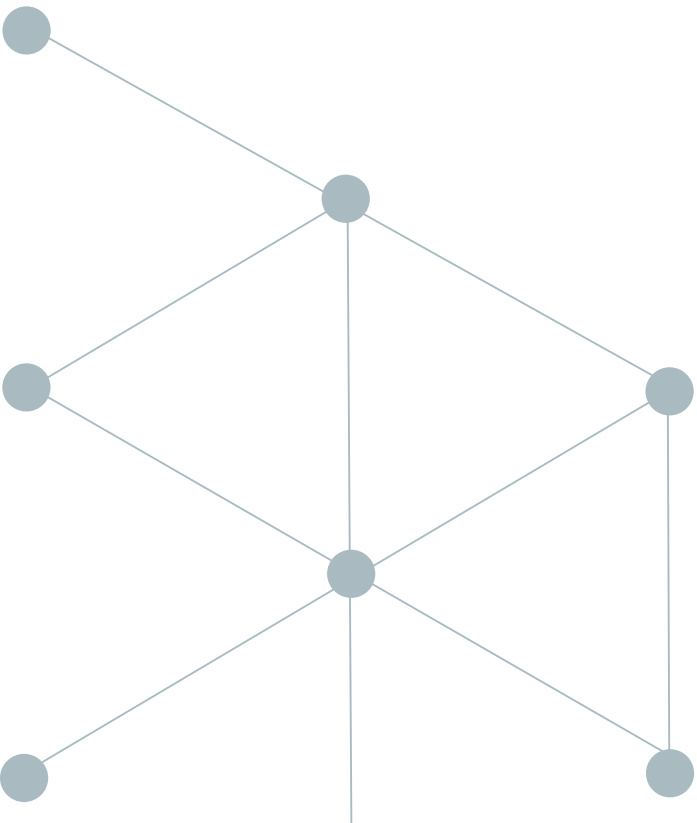
Students gain points in the form of XP points, stars, build points, and in-game dollars. They are used to build your city and afford new developments. Gaining these points is also further incentivised by the prizes mentioned above. Points systems function as a measure of success. Depending on how one fares in the minigame, they are used as rewards which incentivises people to play the minigames and as a result learn English.

Social Features

Though social features were considered lacking by Koivisto & Hamari (2019) in most gamification designs (p.204), they are abundant in Dawn of Civilization. Chat forums, the ability to 'follow' and 'visit' your friends' cities, challenge friends to a minigame battle, create an alliance and even 'pranking' options allows for a social and collaborative environment to thrive.

Feedback on Learning Progress

Another element that is present in the programme but scarce in other gamification applications is the feedback mechanism. As mentioned by Nah et al. (2014), the frequency, intensity and immediacy of feedback are helpful for learner engagement" (p.406). The artificial intelligence in Dawn of Civilization "helps detect what lessons the learners have missed" so that they can "master key skills...faster and more effectively" (Solve Education!, 2020).



Conclusion

In this paper, this author carried out a review of the literature on gamification and has shown that despite the representation of weaknesses, these context-dependent factors are overwhelmed by the quantity and quality of the strengths of gamification. The ability of gamification to engage, motivate and improve students' achievement by transforming the boring traditional classroom into an interactive game-like mission makes it an effective educational strategy. There are also multiple opportunities within the field that, when adequately studied and applied, can seek to make existing weaknesses redundant. However, it is still important that gamifications amplify the value of human teaching, and not be rid of it - thought-out curriculums and designs are still needed for gamification to improve students' learning processes.

This author encourages educators and facilitators to conduct further research on the effects of singular gamification elements (for example leaderboards, or storylines). Most of the research in the studied papers included multiple gamification elements in each application. Studying the effects of singular elements allows future educators to be able to understand the outcomes specific to that input, which enables them to avoid unwanted behaviours that may arise.

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