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Gamification in Everyday Classrooms: Observations From Schools in Hong Kong

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Gamification refers to the use of game elements in non-game context to improve user experience and engagement (Deterding et al., 2011a). The potential of games to make learning more engaging has been widely noted by educators and researchers. Many of the applications and research studies in this area focused on non-customizable digital games that are designed for a specific group and a narrow range of subject content. In actual classrooms, however, non-customizable digital games may not be flexible enough to enable teachers to adapt gamification into practice. Hence, teachers sometimes use a mixed set of strategies to flexibly embed game-based mechanics into their teaching. How can different gamification tools be applied in classrooms? Based on classroom observations and teacher interviews from schools from primary to secondary level in Hong Kong, this paper explores the role of gamification in real practice. We frame the discussion based on the following approaches with ranging levels of flexibility: versatile gamification, gamification platform, and rigid gamification. Versatile gamification was seen as more feasible compared with the other two approaches. We also examine how game-based mechanics such as competition, rules, graphics, and achievements are used to enrich classroom interaction. It was found that gamification is already popular in the classroom. Follow up interviews with teachers suggested that game is a powerful way to engage students. Good practices in game-based lesson design and potentials for further development of gamification tools are discussed.

Keywords: game, gamification, classroom observation, student engagement, lesson design

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INTRODUCTION

"Gamification" is often used as an informal umbrella term that refers to the use of game elements in non-game context to improve user experience and engagement (Deterding et al., 2011b). Despite the lack of a precise and commonly agreed definition, gamification has gained much attention from educators and researchers in various types of study, and the number of commercially available game-related systems with an educational purpose have proliferated (Gros, 2007; Bawa, 2020).

It is widely recognized that educational games are effective in motivating students and make learning much more interesting (Bogost, 2007; ZarraonandiaDiaz and AedoRuiz, 2014). While the rapid expansion of video and mobile gaming has made games ubiquitous, developing new educational games or repurposing existing games to educational setting remains a challenge to many due to the cost, time, and expertise required. Can gamification tools be readily applied in classrooms without a heavy upfront investment of resources?

This paper discusses the applications of gamification in classrooms with examples from a 3-years study, in which the research team visited 14 schools in Hong Kong and conducted follow-up teacher interviews. It was found that gamification has been widely adopted in classrooms, and that gamified education can be achieved through varied means that have varied implications on cost, time and expertise. Based on the findings from our classroom observations and interview, we have identified a spectrum of gamification approaches with varying levels of customizability. In the most customizable end of the spectrum, teachers can combine various digital or non-digital resources to create a teaching and learning game as gamification can be achieved by adding game elements in more abstract levels to increase student engagement and motivation (i.e., versatile gamification). A middle-of-the-road approach is the use of game-oriented tools that are more adaptable with a user-friendly interface that enables teachers to create content related to their learning goal (i.e., gamification platform). The least customizable end of the spectrum is the use of ready-built game-oriented teaching and learning tools with specific content to teach a certain topic (i.e., rigid gamification). The advantages and disadvantages of each approach are discussed, and the implications to educators are highlighted.

What Is Gamification?

Gamification has various definitions by different scholars, each with slightly different scope and emphasis. Some authors distinguish between game-based learning and gamification (Khan et al., 2017), while others use the two terms interchangeably. The two definitions of gamification proposed by Kapp (2012) and Deterding et al., 2011a are particularly noteworthy, with the first one focusing on the **purpose** of gamification and the second on its **design**.

Purpose-Oriented Definition of Gamification

Kapp (2012) defines gamification as the use of "game-based mechanics, aesthetics and game thinking to engage people, motivate action, promote learning, and solve problems". This definition emphasizes the intended use and purpose of gamification (e.g., increase engagement and motivation to do certain tasks), rather than any specific elements of game design (e.g., badges, points, and competition). Kapp's (2012) inclusion of "game thinking" in gamifying everyday activities allows for a broader understanding of gamification in classroom.

Design-Oriented Definition of Gamification

Deterding et al., 2011b elaborate on the design of gaming elements that could be employed to achieve the purpose. A taxonomy of gamification based on the "various levels of abstraction" (p. 12) was proposed. For example, on the most concrete level of game interface design patterns, the presence of common game-related features such as badge, level and leaderboard can be the means to gamify an activity. On more abstract levels, there are game design patterns and mechanics such as utilization of time constraint and limited resources to make the activities more engaging. The game design principles and heuristics further touch on bigger design concepts such as the principle of making the play enduring, making the goals clear and preparing various styles of gaming experiences. On an even more abstract level, game models that can be employed can be associated with fantasy, curiosity or challenges. Lastly, there is the level of game design methods that governs the making process of the gaming design itself, such as using a playtesting method or a playcentric method.

Levels of Abstraction of Game Elements

In brief, there are plenty of gaming elements on different levels of abstraction that may contribute to gamification. Deterding et al., 2011a are also right in indicating that "each of these elements [. . .] taken in isolation, none of them would be readily identified as "gameful" (p. 11). Thus, "'game' is a composite category of multiple necessary conditions" (p. 11). It seems that a good mix of the gaming elements only with an aim to achieve a clear game-related purpose (e.g., increased motivation to participate) is an effective and typical instance of gamification. It is worth noting that while common concrete game elements such as badges, scoring and leaderboard are often used to gamify learning, such elements are not necessary in a gamified lesson, as gamification can occur in a more abstract level by incorporating game design in lesson planning. The cases illustrated in this paper shows how well-designed gaming elements with different levels of abstraction can be applied in classroom setting to engage students and promote learning in the classroom. Both the design (Deterding et al., 2011b) and purpose (Kapp, 2012) of gamification activities are important in conceptualizing gamification in education.

Studies of Gamification in Education

As gamification are increasingly adopted in classrooms, there are numerous empirical studies evaluating the effect of gamification across subjects of study and educational levels (Dichev & Dicheva 2017), as well as extensive discussion on the psychological and theoretical foundation of gamification in different contexts (Krath, Schürmann, and von Korflesch 2021). In a meta-analysis of research conducted on the effect of digital-based gamification using experimental design, Tsai and Tsai (2020) found that students across all educational levels all significantly benefit from game-based science learning. Many recent empirical studies have been done in evaluate the effect of digital game-based learning on learning outcomes across academic subjects such as mathematics (e.g., Deng et al., 2020), physics (Wu et al., 2020), chemistry (Daubenfeld & Zenker 2014) and language learning (e.g., Yang, Lin and Chen 2017). Many of such studies shows that students in the gamification group showed increased attention, positive emotion, or learning motivation compared with the control group, although its effect on academic achievement remains to be debated (Ke et al., 2015). A more recent literature review by Kalogiannakis, Papadakis, and Zourmpakis (2021) also suggested that the use of gamification in education have achieved mixed results with regards to student learning outcome.

Research Gap in Existing Literature

Although the benefit of gamification in motivating student learning is well-established in the literature, many of such research study focused on digital games that are designed for a specific age group and a narrow range of subject content. Hence, such games are not customizable by the teachers, who may be teaching students with characteristics and needs different from the targeted players. For example, the study conducted by Deng et al. (2020) made use of a digital game called Wuzzit Trouble in a Shanghai primary school. The game was developed by the US company BrainQuake to teach basic math concepts and arithmetic operation for third-grade students using a gamified interface. While the student and teacher participants were generally positive about the experience, some teachers commented that the game may not meet the Chinese national curriculum standards and teaching requirements. High quality digital learning games often involve a high cost of development. Although teachers can use those games conveniently off-the-shelf, the lack of customizability of such games entails a tradeoff that some of the games' content may not suit the need of their class. In addition, limitation of the technological equipment was reported as a major obstacle in the adoption of gamification tools (Poultsakis et al., 2021). This leads to the core question to be addressed in this paper: are there other more flexible means of gamification that can be adopted in classrooms to facilitate learning?

METHODS

The present paper looks at gamification in real practice by paying visits to classes in the secondary and primary schools in Hong Kong. The visits were part of a 3-years study supported by the Hong Kong Education Bureau to research on the impact of e-Learning in primary and secondary schools in Hong Kong. Fourteen schools participated in the study, including eight primary, four secondary, two special schools for SEN students. The schools were recruited based on their participation of a government-initiated pioneer project encouraging schools across Hong Kong to adopt eLearning strategies in their teaching. The makeup of the participating schools in term of level of academic achievement is broadly representative of schools in Hong Kong overall.

The full research project is a comprehensive, mixed-method study that aimed at identifying the effectiveness of eLearning using the LEPO (i.e., Learning Environment, Process, and Outcome) framework proposed by Phillips, McNaught and Kennedy (2011). The project employed various research instruments such as collection and comparison of assignment scores, teacher surveys, student surveys as well as classroom observations and interviews with the various stakeholders. The goal of the comprehensive project was to outline the use of technology in teaching and learning in the specific setting and timeframe concerned.

The data relevant to the present paper came from the classroom observations and the follow-up interviews with the teachers conducted between 2016–18. The class observations and the interviews were conducted to observe learning processes, potential challenges and learning outcomes by a professional third-party. A panel of e-learning experts were formed to visit the schools once a year over the 3-year period. Key subjects covered included English, Chinese, Mathematics and/or Liberal Students in secondary schools and English, Chinese, Mathematics and/or General Studies in primary schools. An average of around 30 classroom observations were conducted each year together with the respective follow-up interviews, which were typically conducted shortly after the class was observed. Each classroom observation session lasted roughly between 30 and 45 min and were video-recorded. A structured observation protocol adopted based on Smith et al. (2013) was devised and used by at least two researchers, who marked the protocol independently. Aided by the structured observation protocol, the two observers systematically recorded what the students and teachers were doing in any 5-min time slots. For students, common activities included: listening to teacher, individual thinking/problem solving, working in groups, asking questions etc. For teachers, standard activities included lecturing, real-time writing on board, guiding student work during activie learning task etc. Any discrepancy between the two observers were resolved through discussion. Typically, each classroom has between 20 and 30 students. The teacher interviews were normally conducted on the same day of the classroom observation and lasted between 30 and 40 min. The interviews were audio recorded and then transcribed for later analysis.

The present paper, however, does not comprehensively summarize all the classroom data. Based on the classroom observations, the main purpose of the paper is to find evidence from the data that gamification is in use in the real classroom. Out of all the classroom sessions observed, 13 of them were identified to include substantial elements of gamification. These classroom video recordings and the audio recordings of the relevant teacher interviews formed the empirical basis of this paper. In particular, this paper looks at how different gamification tools can be applied in classrooms to enhance students' learning and attitudinal outcomes? Examples were given to illustrate the many ways of gamification and how they are related to the discussion in the literature. Hence, the purpose of this paper is not to evaluate the effectiveness of the gamification approaches used by the teachers, which has been done by many previous studies, but to identify successful approaches to gamification that can serve as useful references for educators who may develop their lesson plan using similar approaches.

CREATING ENGAGING CLASSROOM ACTIVITIES WITH COMMONPLACE TOOLS

Even though gamification can increase students' learning motivation, there are a number of challenges when it comes to implementing it in classrooms. The complexity of designing an educational game or adopting an existing game for educational use can be a major hinderance for educators. Integrating game elements into existing curriculum require additional effort and expertise from teachers, and the use of

gamification tools can often involve a steep learning curve for teachers and students.

How is gamification being used in the classroom to enhance student engagement? This paper illustrates some examples from our classroom observations in primary and secondary schools. This session discusses some of the effective gamification activities we have observed, with a range of different approaches and digital tools used.

The classroom activities can be broadly categorized into a spectrum of three approaches with varying degree of customizability as shown in **Table 1**.

The gamified activities differ in the type of tools used and the rigidity of the design. "Versatile gamification" refers to a flexible approach of gamification where general purpose, commonplace tools are used to make the learning process more like games; its design can be very versatile, and the user can customize the game flexibly. By contrast, "rigid gamification" refers to single purpose games designed with a narrower set of learning objectives and little room for user customization—often as a part of a publisher-developed interactive content accompanying the textbook. Between the two ends of the spectrum, there is a middle-of-the-road approach that make use of gamification platforms that enable user input of learning content into existing online platforms (e.g., Kahoot! Quizlet) with pre-existing gamified design and interface. The strengths and examples of each gamification approach will be discussed in the sections below.

Using Commonplace Tools to Design Versatile Gamification Learning Experience

Case 1

In a class of Primary five students, the teacher designed a gamified lesson activity using some commonplace, general purpose digital tools. The learning objective was to identify common types of 3D shapes, such as cones and cylinders. Each student was provided with a tablet to take a few pictures of 3D objects they found in the school playground (See **Figure 1**). The students then uploaded the photos they took to the cloud. After the students came back to the classroom, they used a computer to categorize the pictures they took into different types by incorporating the photos into a simple PowerPoint presentation (See **Figure 2**). Students' works were automatically synchronized into the cloud-based learning management platform, and the teacher were able to illustrate the works in class. In another lesson on a related topic, students were asked to create different 3D shapes using the drawing app of tablets. Most students were able to use these commonplace digital tools to complete the tasks.

Implementing a lesson design like the ones described above required much advance planning of the teacher, basic infrastructure (e.g., tablets, stable WiFi) of the school, and technological competency of the students (e.g., using the software). The teacher was able to create an engaging, gamified lesson without the use of specific gamification tools or platforms. Rather, the tools used were all general purpose, commonplace ones such as a tablet for photo taking, cloud-based storage, drawing app, and PowerPoint. By integrating these tools and designing the lesson according to students' ability, the teacher was able to motivate students to complete the learning activity. Although no concrete points or badges were used in this activity, the teacher were able to gamify the learning experience in an abstract level through designing clear goals and time constraints (cf. Deterding et al., 2011a) and create excitement among students by changing the ordinary classroom routine.

The teachers commented in a later interview that students enjoyed viewing the fruit of their own learning (such as the pictures they took). The use of drawing app in for 3D shape also helped to turn abstract shapes into more concrete ones, which was more difficult to accomplish using traditional approach with only pen and paper.

Case 2

Another gamified activity that impressed the research team was in a SEN secondary school. It was a mathematics class and students were told to form into groups of four–five for a shopping role-play game. The teacher gave each student group an envelope with play money and asked the students to visit fast-food websites to plan some shopping for their lunch. The only rule was that they had to make sure they had enough money to pay the food and drink. At the end of the class, they shared what they had "bought", did the calculation in front of the whole class again and explained how much they "paid" (See **Figure 3**).

The researchers in the class observed much excitement and engagement in all the student groups. The students browsed the web pages and did a lot of discussion and calculation to sort out the best way to use their "money". Only very basic technology was needed to make this activity work: just referring students to a real fast-food website. No tailor-made technology was necessary for this activity. It was the addition of the storyline, the inclusion of play money, and the group work setting that made an otherwise common mathematic class on addition and multiplication much more engaging.

Using Gamification Platforms to Create Competition Among Students

Case 3

One commonly used strategy in classroom was to make use of gamification platform to create competition among students to enhance engagement. For example, in a mathematics class of a Primary five classroom we have observed, the teacher made use of Quizlet, an online gamification platform, to make the classroom more fun and engaging. Each student was provided with a tablet in the beginning of the lesson, and the students were randomly divided into groups of three to answer the math questions shown on the tablet. Each group had to answer each multiple-choice question about the area and volumes of certain shapes within a 20-s countdown period. An animated progress of each group was shown in real time on the classroom screen (See **Figure 4**). Each group competed to finish all the questions as quickly and accurately as possible. Some students cheered and jumped up from the chair when their group reached the finish line. After all students have completed the questions, the teacher reviewed students' performance and spent time explaining the questions that were mistaken by a large proportion of students.

In the in-depth interview conducted after class, the teacher said gamification platforms enabled her to set up some questions for students to answer in class. The teacher found that using these

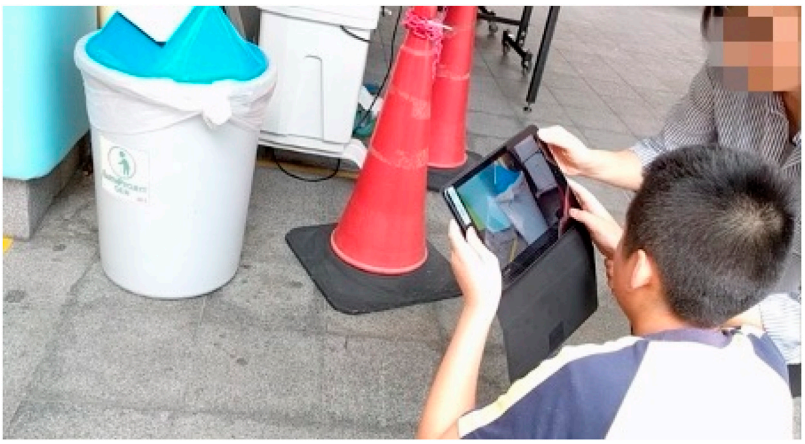

FIGURE 1 | Student took pictures of the shapes observed in school playground, and then incorporated the pictures in a PowerPoint presentation.

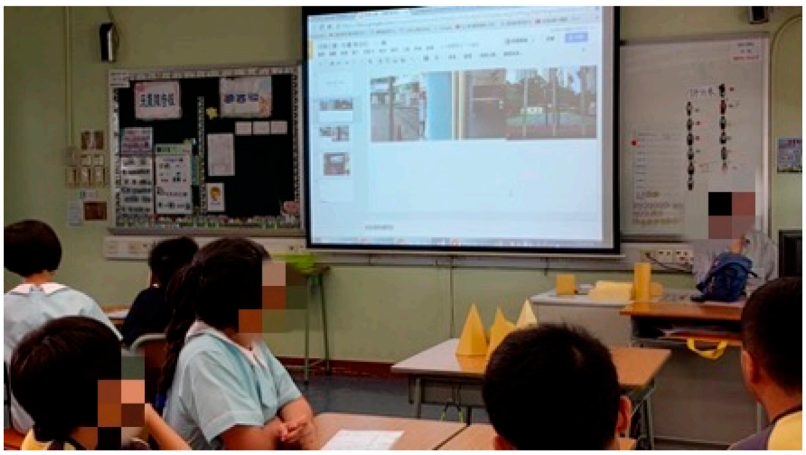

FIGURE 2 | Student took pictures of the shapes observed in school playground, and then incorporated the pictures in a PowerPoint presentation.

platforms helped to make the lesson more interesting to students and create more possibilities for classroom activities. Students felt happy and excited playing games in class using tablets. All the questions were developed by the teachers themselves based on students' level. Since the students' answers can be shown in real time, the teacher can gauge students' understanding of the topic and adjust the lesson accordingly. The gamification platforms have user friendly designs that enabled users to fit in their content easily. The teacher also commented that if tablets are just used as substitute for books, students would not have the same level of engagement—suggesting that the gamified lesson design, rather than the gadget itself, was the decisive factor that motivated student learning.

Using Rigid Gamification Tools to Engage Students Individually

Case 4

In the same Primary five mathematics class, the teacher demonstrated an experimental approach to find out a volume of an object using the water displacement method. The teacher used a real-life container and a jar of water to estimate the volume of an object. Then each student had a chance to try out this approach virtually using their own tablet (See **Figure 5**). Each tablet was pre-loaded with a mini-game designed by the textbook publisher, where students can try their hands on estimating the volume of different objects by doing a virtual experiment. The individual activity lasted for around 10 min. After the students played with the exercise and performed calculations using the tablets, the teacher raised some more challenging questions and invited students to propose new ways to solve them. Students were engaged and were keen on responding to the teacher's questions.

DISCUSSION AND CONCLUSION

Table 2 has a further breakdown of the gaming elements that are associated with the four cases portrayed above. It illustrates game design elements used in the spectrum of different gamification

FIGURE 3 | Students checking up prices in fast food online shop.

FIGURE 4 | Students work in group to compete using Quizlet, with the classroom projector showing each group's progress.

activities, ranging from the more versatile to the more rigid approaches.

Cases 1 and 2 used common technologies such as built-in digital cameras and web browsers and thus did not involve much game interface design patterns as well as mechanics. The gaming elements added to activities were on the more abstract level of rules and game-like psychology. For example, in case 1 the fact that students could go out of the classroom and took pictures everywhere in the school campus broke the everyday routine of a class. The activity aroused curiosity among the students and they enjoyed the adventure involved as they explored the campus hunting for the target shapes. In case 2, game-like psychology was built up by the storyline and the online shopping role-play. The provision of play money further strengthened the students' engagement in the play as it made the story more authentic.

A more sophisticated yet still flexible tool was used in cases 3 with built-in features to achieve gamification, such as an animated scoring board. Each question asked also could have a tight timeframe as the tool kept control of the time. The game-like atmosphere was further strengthened as the teacher introduced new rules and create competition among groups. An even more sophisticated and dedicated tool was used in case 4 to provide the simulations required for students to learn a specific topic. These simulations were topic-specific that the tool was not customizable for teaching other topics. However, it has rich game elements such as attractive aesthetics and animations to engage students. The fact that students may play with it many times to visualize the effect by changing the parameters encouraged students to explore further.

FIGURE 5 | Example of a "virtual experiment" to find out the volume of an object using a tablet.

TABLE 1 | Spectrum of gamification approaches.

	Versatile gamification	*Gamification platform*	*Rigid gamification*
Level of customization	High	Medium	Low
purpose	Can be adapted for a wide range of learning objectives	Flexible range of learning objectives	Single purpose, specific learning objective
Customization of content by teacher	Yes	Yes	No
Design	Very versatile	Flexible with limited format (e.g., multiple choice, short questions)	Rigid
Tool used	Commonplace tools (e.g., camera, calculator)	Gamification platforms (e.g., Kahoot! Quizlet)	Subject specific platforms (e.g., publisher-developed interactive content)
Related examples in the literature	Redesign curriculum content as quest-based game (Kingsley and Grabner-Hagen 2015)	Gamifying lessons using quick quiz software tools (Cheong et al., 2013)	Developing a game to orient new students to library services (Smith and Baker 2011)

TABLE 2 | Game design breakdown in examples.

	Case 1 (Versatile gamification)	*Case 2 (Versatile gamification)*	*Case 3 (Gamification platform)*	*Case 4 (Rigid gamification)*
Game interface design patterns	—	—	Scoring	Trial-and-error
Game design patterns and mechanics	—	—	Time constraint Aesthetic: color	Aesthetic: animation
Game design principles and heuristics	Clear goals	Rules, clear goals	Competition, Rules	Repetition, experimentation, clear goals
Game model	Curiosity, exploration, challenge	Role-play, storyline, challenge	Challenge	Simulation, exploration

Advantages and Disadvantages of Gamification Strategies

There are a few interesting implications based on the findings. For many teachers, versatile gamification can be more feasible and approachable compared with the other two approaches. It is less demanding on the part of the teachers to acquire skills and knowledge to use new computer software. Thus, it is worthwhile for researchers to collect more good strategies that add game elements to common learning resources or activities and then disseminate them to a wide audience of education practitioners.

Nonetheless, there are still many advantages for using gamification platforms and rigid gamification tools. There are ready-made features and content that ordinary learning resources cannot easily achieve, such as the automatic scoring of marks as well as the precise control of time. Game aesthetics is also an important element that enhances engagement. The idea generated from this study is that these activities can be enriched by introducing game elements on the higher levels as well. For example, how about adding a storyline to class exercises apart from merely replying on aesthetics?

Limitation of the Study

The findings of this study are limited by small sample size and scope of the classroom observation. More innovative examples of gamification can be identified from classrooms across other

cultural and educational contexts. Moreover, the effectiveness of gamification strategies was not measured directly in this study, as the current study focuses on the describing learning process more than assessing the learning outcome. Hence, we do not have solid evidence that certain gamification strategies were better or worse than the other in terms of attitudinal or learning outcome. More research is needed to measure the result of various gamification strategies to inform educators about what does and does not work in a specific educational context.

CONCLUSION

Given the rapid development of digital gaming technology, it is a reasonable expectation that future educational games will rise both in sophistication and customizability. Games that are regarded as sophisticated today may be deemed rudimentary in a few years. Games are also likely to become more customizable and easier to develop, as the barrier to acquire the computer programming skills required are lowered over time. Commonly used digital gamification tools in any given time may become obsolete as new technology develops.

Yet the lessons learnt in the cases discussed above will hold true regardless of the level of technological sophistication. Attractive game aesthetic or badges and points are welcomed, though not necessary, features of an engaging gamified lesson. Rather, with some good planning and design on teachers' part, effective gamification can be applied to everyday teaching with remarkable results.

To conclude, gamification is already an approach used in everyday classroom with varied designs and technology. The three types of gamification discussed (versatile gamification, gamification platform, and rigid gamification) are not meant to be exhaustive typology of all possible approaches, but a useful framework for practitioners to consider which approach is best suited to their need. It is hoped that the gamification framework proposed and the examples discussed in this paper will serve as inspiration for educators to integrate game element and design into their lessons. More research would be needed to identify and disseminate good practices of gamification across different educational settings. The good practices should not be defined by the complexity of the technology used but on the learning engagement and learning outcomes generated. In fact, the easier the technology, the easier for it to be adopted by a wider teacher community. More good strategies that lead to engagement and outcomes can be systemically collected and these tips should benefit all types of gamified activities.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Survey and Behavioural Research Ethics Sub-committees, The Chinese University of Hong Kong. Written informed consent from the participants' legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

PL conceived the ideas and key arguments of the article. AT conducted literature review and data analysis. Both authors discussed the results and contributed to the final manuscript.

REFERENCES

Bawa, P. (2020. Game On!: Investigating Digital Game-Based Versus Gamified Learning in Higher Education. *International Journal of Game-Based Learning* 10 (3), 16–46.

Bogost, I. (2007). *Persuasive Games: The Expressive Power of Videogames*. Cambridge, MA: MIT Press.

Caillois, R. (2001). *Man, Play, and Games*. Urbana, Chicago: University of Illinois Press.

Cheong, C., Cheong, F., and Filippou, J. (2013). "Quick Quiz: A Gamified Approach for Enhancing Learning," in The Pacific Asia Conference on Information Systems Proceedings 2013, 206.

Daubenfeld, T., and Zenker, D. (2014). A Game-Based Approach to an Entire Physical Chemistry Course. *J. Chem. Educ.* 92, 269–277. doi:10.1021/ed5001697

Deng, L., Wu, S., Chen, Y., and Peng, Z. (2020). Digital Game-Based Learning in a Shanghai Primary-School Mathematics Class: A Case Study. *J. Comput. Assist. Learn.* 36(5), 709–717.

Deterding, S., Dixon, D., Khaled, R., and Nacke, L. (2011a). "From Game Design Elements to Gamefulness: Defining Gamification," in Proceedings of the 15th International Academic MindTrek Conference 2011, 9–15. 09-28.

Deterding, S., Sicat, M., Nacke, L., O'Hara, K., and Dixon, D. (2011b). "Gamification: Using Game Design Elements in Non-gaming Contexts," in Proceedings of the CHI Conference on Human Factors in Computing Systems, 2011, 2425–2428. 05. doi:10.1145/1979742.1979575

Dichev, C., and Dicheva, D. (2017). Gamifying Education: What Is Known, what Is Believed and what Remains Uncertain: A Critical Review. *Int. J. Educ. Tech. Higher Edu.* 14 (1), 1–36. doi:10.1186/s41239-017-0042-5

Gros, B. (2007). Digital Games in Education. *J. Res. Tech. Edu.* 40 (1), 23–38. doi:10.1080/15391523.2007.10782494

Kalogiannakis, M., Papadakis, S., and Zourmpakis, A.-I. (2021). Gamification in Science Education. A Systematic Review of the Literature. *Edu. Sci.* 11 (22), 22. doi:10.3390/educsci11010022

Kapp, K. (2012). *The Gamification of Learning and Instruction*. San Francisco, CA: Wiley.

Ke, F., Xie, K., and Xie, Y. (2015). Game-based Learning Engagement: A Theory- and Data-Driven Exploration. *Br. J. Educ. Technol.* 47, 1183–1201. doi:10.1111/bjet.12314

Khan, A., Ahmad, F. H., and Malik, M. M. (2017). Use of Digital Game Based Learning and Gamification in Secondary School Science: The Effect on Student Engagement, Learning and Gender Difference. *Educ. Inf. Technol.* 22 (6), 2767–2804. doi:10.1007/s10639-017-9622-1

Kingsley, T. L., and Grabner-Hagen, M. M. (2015). Gamification. *J. Adolesc. Adult Liter* 59 (1), 51–61. doi:10.1002/jaal.426

Krath, J., Schürmann, L., and von Korflesch, H. F. O. (2021). Revealing the Theoretical Basis of Gamification: A Systematic Review and Analysis of Theory in Research on Gamification, Serious Games and Game-Based

Learning. *Comput. Hum. Behav.* 125, 106963. doi:10.1016/j.chb.2021.106963

Looyestyn, J., Kernot, J., Boshoff, K., Ryan, J., Edney, S., and Maher, C. (2017). Does Gamification Increase Engagement with Online Programs? A Systematic Review. *PLoS One* 12 (3), e0173403. doi:10.1371/journal.pone.0173403

Phillips, R. A., McNaught, C., and Kennedy, G. E. (2011). *Evaluating E-Learning: Guiding Research and Practice*. New York & London: Routledge.

Poultsakis, S., Papadakis, S., Papadakis, S., Kalogiannakis, M., and Psycharis, S. (2021). The Management of Digital Learning Objects of Natural Sciences and Digital Experiment Simulation Tools by Teachers. *Adv. Mobile Learn. Educ. Res.* 1 (2), 58–71. doi:10.25082/amler.2021.02.002

Smith, A. L., and Baker, L. (2011). Getting a Clue: Creating Student Detectives and Dragon Slayers in Your Library. *Reference Serv. Rev.* 39, 628–642. doi:10.1108/00907321111186659

Smith, M. K., Jones, F. H., Gilbert, S. L., and Wieman, C. E. (2013). The Classroom Observation Protocol for Undergraduate STEM (COPUS): A New Instrument to Characterize university STEM Classroom Practices. *CBE Life Sci. Educ.* 12 (4), 618–627. doi:10.1187/cbe.13-08-0154

Tsai, Y. L., and Tsai, C. C. (2020). A Meta-Analysis of Research on Digital Game-Based Science Learning. *J. Comp. Assist. Learn.* 36, 80–294. doi:10.1111/jcal.12430

Vu, P., and Gaskill, M. (2018). "Can Pre-service Teachers Create Digital Game-Based Activities without Coding Knowledge," in *Gamification in Education: Breakthroughs in Research and Practice*. Editor I Management Association, 159–172. doi:10.4018/978-1-5225-5198-0.ch009

Wu, C., Tzeng, Y., and Huang, Y. (2020). ;Measuring Performance in Leaning Process of Digital Game-Based Learning and Static E-Learning. *Educ. Technol. Res. Dev.* 68(5), 2215–2237.

ZarraonandiaDiaz, T. P., DiazRuiz, P. M. R., Aedo, I., and Ruiz, M. R. (2014). Designing Educational Games through a Conceptual Model Based on Rules and Scenarios. *Multimed Tools Appl.* 74 (13), 4535–4559. doi:10.1007/s11042-013-1821-1

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