HJSTEM
Hellenic Journal of STEM Education, 3(2), 17-19, 2024

www.hellenicstem.com
ISSN: 2832-840X

EDITORIAL

Bridging research gaps in gamification in science education

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Abstract
Playing and learning are fundamentally connected, and in this editorial, I outline according to which criteria educational processes can be gamified. As a next step, I attempt to discover key arguments that justify the value of games in the classroom. Especially in today's times of uncertainty, games can, for example, contribute to questioning science-related information and to reflecting corresponding discourses on controversial topics. I call for papers on gamification in science education, especially in the light of current challenges.

Keywords
science education, gamification

• Received 22 December 2022 • Revised 22 January 2023 • Accepted 22 February 2023

A look back
For quite some time now, I have been working on learning through play in chemistry classes. I already published an editorial on this topic in 2021 (Belova, 2021), and in the rather short time since then, a number of trend-setting publications have appeared, which prompts me to write an update of my text at that time. Here I focus on a new aspect, namely the use of games to promote critical reflection.

Between playing and learning (science) – an update
In the following, I will summarize the most important connections between playing and learning. Every culture and society around the world have a form of play that is fundamental to human activity (Roberts, Arth & Bush, 1959). For hundreds of years, renowned psychologists and educators such as Montessori and Piaget have recognized the value of play for children's development (Murray, 2018). The importance of games for personal development has led to the use of game-based learning settings in both secondary and postsecondary education (Kim, Song, Lockee & Burton, 2018). In terms of overarching theories, gamification elements that constitute effective learning games can be linked to the central theories of constructivism (Hayhow et al., 2019), namely social constructivism (and communities of practice) and situated learning (Kafai & Burke, 2015). Some researchers might even consider educational games to be one of the biggest "hypes" of the last decade in the educational context (Raitskaya & Tikhonova, 2019, p. 5), but from my perspective, this "hype" has not yet reached our community fully. But how are the concepts of "playing" and "learning" interrelated?

First of all, it's not so easy to define what exactly a game is, although we all have an everyday understanding of it. Kim, Song, Lockee, and Burton (2018) compared a range of criteria from different publications and identified three key aspects that I believe are also functional for our considerations as educators: Goals (desired outcomes of the game), rules, and interactions (reciprocal actions between players). Commonly mentioned elements for gamification explicitly in learning and education (or simple game-based learning) go in line with these general aspects and are story, dynamics, mechanics, collaboration, goal-oriented design, set of rules and technology (Aynsley, Nathawat & Crawford, 2018; Kim et al., 2018) However, this does not mean that specific elements must be used for gamification in learning and education. Also, using many gamification elements does not guarantee more effective gamification or better results (Mora et al., 2017). Based on the given conditions, educators should select necessary gamification elements to create an integrated solution that solves learning and education problems (Kim et al., 2018).

Games in the school context are sometimes criticized for overemphasizing their entertainment and competitive aspects while neglecting their intended educational purposes (Westera et al., 2008). In order to create or reuse a game setting effectively, it is essential to thoroughly plan the educational uses. On the other hand, games have certain positive effects such as the increase of motivation due to their competitive character or fostering problem solving skills (Kim et al., 2018). The positive features of games have been related to theories of motivation (Sailer et al., 2017), self-determination (Deci & Ryan, 2008), and achievement goal theory (Pekrun et al., 2014). An explicit advantage of gamification in learning is that well-designed games "automatically" increase students' learning (Newmann, 1992) – you lose track of time, without even realizing that you are learning. This is known as the state of "flow" (Csikszentmihalyi, 1990).

Despite all of these positive aspects, the educational value of games in terms of their effect on content learning remains uncertain (Young et al., 2012). Based on the research findings available so far, Tsekleves, Cosmas and Aggoun (2016) as well as Kim, Song, Lockee and Burton (2018) developed several quality criteria that educational games should possess to increase the probability of both motivational as well as educational effects. Games in educational frameworks should, among other aspects, be aligned with the curriculum, have clear learning goals like progression or repetition, be interactive, contain aspects which can be used for assessment and feedback purposes and thus allow students to check their own progress. In addition, a large meta-analysis on game-based learning in chemistry education recently published shed a little more light

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https://doi.org/10.51724/hjstemed.v3i2.29

on the issue (Hu et al., 2022). They found that game-based learning does have positive effects (compared to other teaching methods) in the areas of cognition, retention, and motivation, although many of the studies considered had very small samples. A large gap exists around emotion, for example, in the question of the extent to which games in chemistry classes trigger positive emotions and prevent negative ones. There is therefore still great research potential in this area.

A very recent trend that I am currently observing is the use of games to foster critical media literacy. We live in an increasingly complex world, also referred to as the 'post-truth world' (Barzilai & Chinn, 2020). Many of the topics discussed, especially on social media have a scientific background, but only in the rarest of cases are actual experts speaking here. Because anyone can create and share content on platforms such as Instagram, Facebook and TikTok (thus eliminating the previously existing media gatekeepers), misinformation can spread rapidly and in extreme cases can lead to social divisions, as can currently be seen in the debates surrounding the COVID-19 pandemic (Archila et al., 2021). To foster skills that enable students to distinguish between credible information and misinformation as well as reflect on communication mechanisms several games were published during the last few years. For example, Roozenbeek and van der Linden (2019) developed an online game for detecting misinformation and corresponding spreading strategies: players take on the role of news producers and have to actively apply certain strategies (such as polarization or emotionalization), while being explicitly warned in the game about potentially manipulative activities; in a pre- and post-test design, the game was shown to significantly reduce the perceived reliability of tweets that used several common strategies of online misinformation. A very recent game on a science-based topic, namely climate change, addresses, among other things, the reenactment of certain rhetorical devices as a kind of "challenge" (Cook et al., 2023). I think such approaches are very promising and advocate for further development projects.

Call for papers

As mentioned above, there is still not enough evidence on the positive effects of games for teaching and learning of science as well as a lack of best practice examples of games that worked well for a specific educational purpose, especially in the light of current challenges. I therefore encourage to contribute respective studies to HJSTEM.

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