

Investigating the Effect of Games on the Learning Experience in the Science Classroom

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Clodagh is a science and biology teacher. In 2018 she completed a general science degree, specialising in physiology in Trinity College Dublin, and then completed a professional master's in education in Trinity and qualified as a secondary school teacher. Clodagh is interested in getting students excited about science and learning about themselves and the world around them through the eyes of science. She believes that education should be engaging, collaborative and that it can be fun, and has a keen interest in games in education to promote a more positive and effective learning environment.

KEYWORDS: Gamification, Game-based Learning, Science Classroom, Secondary Education.

INTRODUCTION

Students often lose interest in science when they get to post-primary school (Murphy, Mullaghy, & D'Arcy, 2016) and games can be useful in engaging and motivating students. This article is part of a larger study which aimed to investigate the use of games as a pedagogical tool; specifically, to see if games can promote a more effective learning environment than more traditional teaching methodologies in the science classroom. There are two terms frequently used in relation to using games as a pedagogical tool; game-based learning and educational gamification. Game-based learning is a teaching method where students gain and apply knowledge through game play, whereas gamification of education is the application of game elements in learning to motivate students (Al-Azawi, Al-Faliti & Al-Blushi, 2016). These terms will be used as a lens to investigate the effect of games on learning.

The objective of this research was to find out if games have an effect on student engagement levels, and also what impact games have on the achievement of learning outcomes, particularly in science. These objectives led to the formulation of the research questions. The research questions that were investigated are:

1. How do active learning methodologies such as games affect student engagement in science?
2. What impact does game-based learning or gamification have on the achievement of learning outcomes in science?

The methodological approach taken was that of a systematic literature review. Research papers were found using the education database Education Resource Information Centre (ERIC), and were reviewed and analysed in relation to the research questions. These papers were all peer reviewed research articles that implemented a game intervention in the science classroom internationally.

CONTEXT

In a speech to the *Royal Society of Arts* in London in 2008, Ken Robinson, the world-renowned educationalist, discussed the need to change the paradigm of education. In this speech, he discussed how the current education system that we have was thought of and built for an entirely different age. He then went on to argue that our students are living in the most intensively stimulating period of time on earth. Students are constantly bombarded with highly stimulating technologies. It must come as no surprise then that students can find it difficult to concentrate in class when their attention is constantly being diverted or re-directed. Robinson went on in this speech to suggest that lessons need to come alive to compete with outside distractions to get our students' attention (*Changing Education Paradigms: Sir Ken Robinson*, 2008). One way to do this is by using games in the classroom.

Games have been used in education for many years as a way to entice and engage learning. Educational games should combine elements of fun with educational concepts to promote a positive learning environment (Al-Azawi et al., 2016). Nowadays games play a large role in young peoples' lives, especially digital games (Chang, Chen & Yeh, 2016*). It is thought that the constant use of more traditional teaching methods which result in more passive learning is not meeting the needs of our ever-evolving times (Broadfoot, 2000).

The use of games can help to promote a positive learning environment which should help promote better learning outcomes. Games or game elements can be useful for motivating students to learn as well as providing a common experience base for the students. They also can

allow for ideas or concepts that can be complicated or abstract to be demonstrated (Chow, Howard & Lambe, 2008). This can be particularly prevalent in the science classroom as students can at times struggle to conceptualise different ideas in science due to the abstract nature of it (Lay & Osman 2018*).

There are different ways to incorporate games into education, such as game-based learning and educational gamification. Game-based learning uses games to enhance the learning process (Kim, Park & Baek, 2009) and gamification uses game elements such as points or levels to make the learning experience more game-like (Çeker & Özdamlı, 2017).

The more traditional method of teaching where teachers talk and students passively absorb information can seem quite dull in today's fast paced society. Csikszentmihalyi is a psychologist who coined the concept of 'flow'. Flow is experienced when a person is willing to undertake an activity for its own sake with little worry or concern for what they will get out of the activity (Csikszentmihalyi, 2009). This experience of flow is an optimal state of immersed concentration. To attain flow a task must pose enough of a challenge for students depending on the skill level that they have. If the task is too easy for their skill level it could cause boredom, and if the task is too difficult it could cause anxiety. Distraction and outside stimuli can have a negative impact on this experience of flow. The intrinsic satisfaction of flow is not always provided by passive, teacher led learning but could be facilitated by student-centred active learning (Csikszentmihalyi, 2009).

Active learning is a term that describes a broad range of models of instruction. In basic terms, active learning is where students are held responsible for their own learning. Some examples of active learning methodologies are experiential learning, problem-based learning, participative learning and co-operative learning (Michel, Carter & Varela, 2009). With a student-centred approach students can build a better capacity for solving problems and reasoning. When a student finds the solution by themselves, even with guidance, it is likely to be more meaningful and the student is more likely to remember it than if they were a passive recipient of the knowledge (Gillies & Haynes, 2010).

While theory would suggest that games should be useful in helping students to achieve better learning outcomes, the aim of this research was to investigate and see if research finds that games affect engagement in science classrooms and does this in course have an effect on the achievement of learning outcomes in the science classroom.

METHODOLOGY

The methodology chosen for this thesis is that of a systematic literature review. The database used to search for literature in this systematic review was Education Resources Information Centre (ERIC). Search terms were selected and put into this database. A protocol was carried out to select suitable papers in relation to the research questions.

A systematic literature review can be defined as “a review of a clearly formulated question that uses systematic and explicit methods to identify, select, and critically appraise relevant research, and to collect and analyse data from the studies that are included in the review” (“Glossary | Cochrane Community”, 2020). A systematic review starts with a research question, then identifies all relevant studies, and finally, using a scientific methodology, summarises the results (O’Brien & McGuckin, 2016).

The overall aim of the systematic review is to give coherent targeted answers to specific questions. The systematic review has particular methods so that reliable and valid results can be produced (Hemsley-Brown & Sharp, 2003). These methods help in making sense of large bodies of information (O’Brien & McGuckin 2016). The systematic review approach does this by analysing evidence from empirical studies that are of a high standard and have appropriate design (Hemsley-Brown & Sharp, 2003). The protocol for selecting suitable papers to analyse are listed below:

- Step one: Input search terms to assigned Database
- Step two: Apply inclusion and exclusion criteria
- Step three: Read titles and abstracts retaining any articles that are relevant to the research.
- Step four: Make preliminary selections by re-reading abstracts, scanning content and retaining articles that are of most relevance to research questions
- Step five: Final selection of documents for critical analysis.

To select the final papers, the finalised inclusion and exclusion criteria were applied.

Inclusion Criteria	Exclusion Criteria
All research should be peer reviewed	No use of a pre and post test
Game intervention implemented	
Focused on science education	No control or comparison groups
Focused in secondary school settings	

Table 1: Inclusion and Exclusion Criteria

Using this criterion there were five papers chosen to be further analysed. These five papers all gathered data or discussed areas surrounding the effect the games had on the level of engagement of students as well as the learning outcomes.

FINDINGS AND DISCUSSION

Using the protocol and the inclusion and exclusion criteria set out in table, five papers were chosen for an in-depth analysis. These papers were all peer reviewed and involved a classroom intervention of a game (Bunch, Robinson, Edwards & Antonenko, 2014*; Chang, Chen & Yeh, 2016*; Khan, Ahmad & Malik, 2017*; Lay & Osman 2018*; Ye, Hsiao & Sun, 2018*). These papers that were included in the analysis were signified with an Asterix. These papers were then analysed to answer the research questions.

RESEARCH QUESTION ONE: “HOW DO ACTIVE LEARNING METHODOLOGIES SUCH AS GAMES AFFECT STUDENT ENGAGEMENT IN SCIENCE?”

Student engagement was measured in a wide variety of different ways. Out of the five papers included in this analysis, four gathered and analysed data directly related to student engagement (Chang, Chen & Yeh, 2016*; Khan, Ahmad & Malik, 2017*; Lay & Osman 2018*; Ye, Hsiao & Sun, 2018*). One of the studies did not measure the engagement of students directly but did stress the importance of games in engaging students in science (Bunch, Robinson, Edwards & Antonenko, 2014*). Out of the four papers which did measure the students' engagement in class and outside of class in the topic of interest, three papers found that there was an increase in engagement in the students who took part in the game intervention compared to students who had more traditional teacher-led class.

It is thought that active learning through game-based learning or gamification induces increased levels of engagement from students. Games are inherently interactive and this works well in grabbing and holding students' attention. Interactivity is a game element that was used by all the game interventions in the studies included in this analysis. In one paper, boys had a lower level of engagement than girls in the intervention group and it is thought that the reason for the lower engagement levels in the boys is that the game was not interactive enough (Khan, Ahmad & Malik, 2017*).

The games used in these studies often immersed students in real life situations (Bunch, Robinson, Edwards & Antonenko, 2014*; Khan, Ahmad & Malik, 2017*; Lay & Osman 2018*). This allowed students to make connections in science with everyday life. This can help students to visualise different situations and concepts. This immersion can help to clear up any

misconceptions that students may have due to the abstract nature of certain topics in science. Students can get frustrated and disengaged when they find they cannot visualise a certain topic. By immersing students in a topic or situation using a game this frustration can be eased and engagement increased.

One aspect of games that was seen to increase student engagement was the entertainment factor of games. Many of the games used in the studies were fun to play and enticed students to play voluntarily. Students found enjoyment from playing the games and from this emotional engagement was seen to increase (Khan, Ahmad & Malik, 2017*). It has been pointed out that learning should not merely be the acquisition of knowledge but it should also be fun so that students participate voluntarily (Lay & Osman 2018*; Ye, Hsiao & Sun, 2018*). It is important to note however that engagement is only part of the learning experience and that the level of achievement of learning outcomes also needs to be explored.

RESEARCH QUESTION TWO: WHAT IMPACT DOES GAME-BASED LEARNING OR GAMIFICATION HAVE ON THE ACHIEVEMENT OF LEARNING OUTCOMES IN SCIENCE?

In the papers included in this analysis only two of the studies saw an improvement in student learning outcomes in students who took part in the game intervention compared to those who participated in more conventional teacher-led learning (Lay & Osman 2018*; Ye, Hsiao & Sun, 2018*). In the other three papers there was no significant difference between groups in their achievement of the learning outcomes (Bunch, Robinson, Edwards & Antonenko, 2014*; Chang, Chen & Yeh, 2016*; Khan, Ahmad & Malik, 2017*), in these studies both the intervention and control group achieved the learning outcomes to similar levels.

In all of these studies the interventions were carried out in a single school. In each of these studies the intervention groups had slightly higher average scores, but not enough to reach a statistical significance. It is possible that the numbers of students that they were examining was not big enough to reach a statistical significance. If each of the interventions were carried out in multiple schools or over a longer period of time this may have resulted in different outcomes.

It was noted that while students in the game intervention groups did not improve in the achievement of learning goals, they also did not diminish the level of achievement the student reached compared to those who had more conventional teaching (Bunch, Robinson, Edwards & Antonenko, 2014*; Khan, Ahmad & Malik, 2017*). Games were found to be equally as effective as traditional teaching in terms of reaching learning outcomes. It was thus

recommended that games should be used in the classroom without fear that they will diminish learning (Bunch, Robinson, Edwards & Antonenko, 2014*).

This means that while they did not improve on the learning outcomes compared to the control group, the interventions still had beneficial components that helped the students to reach the learning goals. The beneficial components of these interventions that were commonly discussed are motivation due to game elements, collaborative learning, learning by inquiry and the repeated mastery that games allow. Games, when implemented properly can have the effect of increasing students' motivation to do work. There are aspects of games that can make students want to achieve.

Two of the studies that showed improvements in learning outcomes in their intervention groups compared to the control groups used collaborative learning in their interventions either directly through the game play or through group discussion after the game play (Lay & Osman 2018*; Ye, Hsiao & Sun, 2018*). It is suggested that peer learning can promote better understandings and clear up misconceptions. Peers can input ideas that cause cognitive conflict and this can lead to existing ideas being reconstructed and thus a deeper level of understanding (Lay & Osman 2018*).

Students acting as a game designer promotes higher order thinking with creating being on the top of Bloom's Taxonomy. This would aid in promoting better learning outcomes as the higher you go in blooms taxonomy the deeper the level of understanding (Plass, Homer & Kinzer, 2015). Overall games can be seen to improve students' engagement in science while also maintaining the same level of achievement of learning outcomes that can be seen with more conventional teaching methods.

CONCLUSION

In the general literature the idea that active learning may be more beneficial than passive learning was discussed as well as the psychology behind using games in education and the different ways in which games are used in education. A general literature review led to the formulation of the two research questions. Five papers were chosen to be analysed with the two research questions in mind.

The impact that games have on students' engagement levels was generally positive. The papers showed that, for the most part students in the game intervention groups were more enthusiastic about taking part in the lessons compared to the control groups. (Chang, Chen & Yeh, 2016*; Khan, Ahmad & Malik, 2017*; Lay & Osman 2018*; Ye, Hsiao & Sun, 2018*) The one paper that did not show an increase in student engagement stated that this was due to

the game being too easy and so students quickly became disinterested (Chang, Chen & Yeh, 2016*). The common reasons for the increase seen in engagement levels across the board was the interactivity of game, the entertainment that games can provide and the student-centred nature of the interventions. The games enhance the students experience of flow, where they participate in the task voluntarily, but only if it is giving the students enough of a challenge (Csikszentmihalyi, 2009).

While games were generally seen to increase engagement levels, the next research question was seeking to find out if students' level of achievement of the learning outcomes would be affected by the use of games or game elements. One might think that an increase in engagement levels would ultimately lead to an increase in the level of achievement in the learning outcomes, but this was not always the case. In the five papers included in the analysis, only two of them saw an improvement in the learning outcomes of the students who were part of the intervention group compared to the control group (Lay & Osman 2018*; Ye, Hsiao & Sun, 2018). It was noted in the other three papers however that there was no significant difference in the learning outcomes between the intervention and control groups (Bunchet al., 2014*; Chang et al., 2016*; Khan, Ahmad & Malik, 2017*). This means that the use of games was just as effective as the more conventional teaching methods in terms of reaching the learning goals. There were several suggestions in the papers as how games aid student to reach these learning goals. Some of the common reasons given in the papers were increased motivation due to game elements, collaborative learning, learning by inquiry and the repeated mastery that games allow.

In general, the papers were positive about the use of games in the classroom and encouraged teachers to utilise games in their practise. The games had beneficial effects on engagement levels when implemented properly. They also did not diminish the quality of learning that took place.

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