



Murillo Cabeza, I. (2021). Revising while playing: development and evaluation of the newly created Microbial Pursuit game as a pedagogical tool in higher education. *FEMS Microbiology Letters*, 368(16), Article fnab101. <https://doi.org/10.1093/femsle/fnab101>

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Revising while playing: Development and evaluation of the new created Microbial Pursuit game as a pedagogical tool in higher education.

Key words: revision, learning, game, pedagogical, higher education, microbiology.

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Abstract

Playing games is an invaluable and widely used educational tool in both primary and secondary schools and there is an increasing interest in building games into the curricula in the Higher Education system. This project involves the creation and playing of a board game with questions on a science discipline. Questions and answers are collaboratively made by the students based on the unit material. It is therefore in both the making and in the playing of the game that learning takes place. The game contains not only a collaborative element but also one of competitiveness as the students play with and against their colleagues. Both these elements are designed with the intention of enhancing student engagement with the topic of microbiology. The game, called Microbial Pursuit, represents a versatile tool for converting tutorials and workshops into pedagogical and enjoyable sessions, as well as a promising unit revision tool.

Introduction

Universities are increasingly interested in modifying conventional educational methods, that although effective, could be improved by including interactive activities with the aim of promoting the development of students as deep learners (Subhash and Cudney, 2018). For some disciplines such activities are part of the curriculum, while for others this is more challenging to achieve.

Undoubtedly there is no more interactive activity than playing games, which is an invaluable and widely used educational tool in both primary and secondary schools (Mann, 1996). Students move through their education and ultimately find that games are not part of the Higher Education curriculum. The lack of this type of interactive element is being addressed by an increasing interest in the use of games in

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academia. This is also reflected in the number of studies dedicated to evaluating the use of games in education (Koivisto and Hamari, 2019). But why are games being rediscovered now? There is a growing believe in the constructive potential that games offer. So positive is the experience of students and educators with the use of games, that the academic term of "gamification" has been proposed for the use of elements of games in a non-game context (Deterding, 2011).

Gamification is also used in corporate training as an important part of their learning strategies. Employers find that this practice provides the trainees with better recall and retention, helps to improve performance and provides a safe environment to practice and obtain the required skills (Obaid, 2020).

Similarly in education, gamification can also provide a safe environment that encourages students to take risks, to fail and to think outside of the box. Gamification can also be used to motivate those students who find it difficult to engage with the topic (Sailer, 2017). Games should also provide an opportunity for students to collaborate as some students can feel uncomfortable being competitive with their peers. It is important to make students understand that games are not just for fun, most contrary they are an invaluable resource of knowledge (Mann, 1996).

When preparing an academic course, educators should consider introducing gamification as part of their curriculum. With endless possibilities, it is important that educators as game designers carefully plan the amount of gamification elements, their combination and their position in a particular context (Warmelink, 2020) and, importantly, the evaluation of the incorporation of gamification and whether it achieves the intended results and to act accordingly. The key elements of the game mechanics that should be carefully planned when creating an educational game are (Robson, 2015):

1. Challenges (learning goals)
2. Complexity and Levels (learning path)
3. Instant feedback (to aid progress)
4. Scores (accomplishment and gratification)
5. Type of interactions such as competition (to assess where you stand against others) and collaboration (when multiple teams play).
6. Players' experience (this will dictate the type of engagement with the game)

The framework elaborated by Bloom and collaborators (Bloom, 1956) is a crucial element to consider when designing the role of the student and the intended learning outcomes that want to be achieved in an educational game. In that sense, games can be incorporated as a tool in science education (Ellington, 1981; Franklin, 2003; Bonde, 2014) with the objective of reinforcing the material taught. Games can help to minimise the total amount of information the student needs to memorise, maximise the learning time, as well as help students become independent learners by understanding, discussing, analysing and applying the components of taught material during the process of the game. Gamification of the unit material contributes

to creating a relaxed atmosphere in the classroom, which facilitate the social interaction of students. The involvement of the students in the construction of the game is essential for the outcome of student learning and it should aim to follow the words of the philosopher Confucius (450 BC), who said: “*Tell me and I will forget. Show me and I may remember. Involve me and I will understand*”.

This manuscript presents the development of a newly created card game called Microbial Pursuit aimed to enhance the student learning experience in the field of microbiology in higher education. Students are an active part of the game; they are not just participants but also creators (Hallett, Tomlinson and Procter, 2018), as the game is based on the implementation of student-generated questions and answers. The objective of this game is not to provide new content but to reinforce existing knowledge by facilitating the unit revision. Many studies support the use of student-generated questions as this type of activity enhances personal engagement with the course content. It also improves the student’s confidence when using the taught material in the making of the game questions. A further benefit results when the student chairing the game has to provide the correct answer while explaining why other options are not correct (Pittenger and Lounsbery, 2011), leading to a greater depth of learning. The dynamic of the game also provides instant feedback and its consequent benefits (Kulik and Kulik, 1988).

This pilot project aims to develop a new educational game and test its effectiveness as a supplementary pedagogical tool with a potential revision element. The collaboration of students is fundamental to achieving a further aim of this project, namely that through the process of creating the game, students interact with each other, which in terms leads to a relaxed, inclusive and effective learning environment that can potentially build up the sense of student cohort (Martin, 2017; Song, 2017).

Materials and methods

This pilot project was carried out at the University of Bristol to investigate the use of Microbial Pursuit, a newly created game, as an educational tool. The project was composed of two parts. The first part was dedicated to the development of the game funded by the Bristol Institute of Learning and Teaching (BILT) and the second part was the applicability of the game as a supplementary teaching tool, the test of the game and its qualitative evaluation.

During the first part of the project, several steps were taken to design and create the game:

Game planning: research and preparation of material were carried out during this stage.

Game development: this step included the design, establishment of the mechanics of the game and the making of the components of the game. The cards and game board designs were derived from other well-established board games such as Trivial Pursuit and Gutsy. The components of the game were re-designed with Adobe Photoshop and printed by the University of Bristol Printing services. The final version

of the board game was printed in Foamex by an external company. Foamex is a light material that allows the components of the game to be transported easily across the campus but at the same times provides a professional look. The colour and icons in the board game match the design of the cards. The rules of the game were adapted as the game was tested.

The second part of this pilot project focused on student participation and their involvement:

Game creation and play: students worked in groups of 6 over several one-hour long sessions. During the first session, each group was asked to write a number of questions on their specific Microbiology topic. The groups were divided by colours, and there is a total of six colours (orange, yellow, green, blue, pink and purple). Each colour was assigned a set of lectures according to the syllabus of the Microbiology unit. Students used class handouts, laboratory practical material and the internet as a source of information to create different types of questions, and where possible, questions were similar in style to those the students encounter in their examinations.

The questions and answers were collected in a word document and sent to the academic leading the game to be checked for accuracy and then printed and were ready to be used. During the second and third sessions, students were divided into new groups and played the game. Each group was provided with a game board, a set of cards, dice, wedges and wedges holders (figure 1). As one of the aims of the game is to help students with unit revision, sessions were scheduled around midterm and final exams. The second session helped to test the game elements and rules while the third session was used to adjust the rules.

As questions and answers are newly created, and therefore always different, as it depends on the material taught and the creativity of the groups, the cards are printed with a blank space. The questions and answers are printed on standard paper, cut to size and inserted into a plastic sleeve together with the corresponding coloured game card. With this sustainable and versatile approach, cards can be used for any other unit as the questions and answers are easily exchangeable.

All sessions were run in a new space created at the University of Bristol designed to stimulate student interaction. This type of classroom has a capacity for 150 students and is furnished with multiple oval tables, each of which accommodates up to 8 students. Each table is attached to a computer and a flat screen facilitating the sharing of the researched and written material (figure 2).

Qualitative evaluation of the game: in order to evaluate the game students of the same cohort attending the sessions were asked to fill in a questionnaire voluntarily and anonymously (table 1) and were encouraged to give oral feedback to the academic team supervising the activity after each session. Sixty-eight questionnaires were collected, and their answers were then analysed and normalised by the numbers of attendees and plotted in a graph (figure 3). A 10-point scale was used to evaluate the questionnaire. This work adhered to institutional ethical requirements.

Results and Discussion

Due to the nature and the timeline of the project, only a qualitative evaluation was possible. The evaluation was focused on the effectiveness of the game as an interactive, sociable and engaging educational tool in the field of microbiology. This was possible by running three sessions with first-year microbiology students, who generously gave their free time to help. The evaluation was based on both student written and oral feedback and observations from the academic team after each session.

The first and second sessions were very interactive, students were keen on actively participating, firstly by making the questions and answers and secondly by playing the game. Students were encouraged to talk informally and to share the material provided, which created a very relaxed atmosphere, facilitating an effective informal learning environment. Each group was very self-organised. Academics did not observe students showing any difficulty in distributing the different roles required for the group tasks (e.g., scribe, finding the unit material, reading the game rules, etc.). The social interaction between students was active and lively across the classroom which is considered important and essential (Martin, 2017), especially for first year students as it offers an ice-breaking opportunity with new peers which might create or enhance friendship. The third session ran very smoothly as the students were used to the dynamics of the game; the adjusted rules made the game more fluid.

Students were asked to fill in a questionnaire after each session (table 1). The oral and written feedback received from students has been both positive and very encouraging. The questionnaire was divided into different sections with the idea of acquiring information on the perception of the students about the organisation of the sessions, the value of the game and their willingness to repeat the experience. The data presented in figure 3 shows that all the attendees felt that the sessions were very well organised. All students attending both sessions agreed that participating in the game was a good alternative educational method and felt that Microbial Pursuit had added value to their learning. All of the students would encourage the use of this type of alternative educational methodology in other units. Most of the students felt that the game enhanced their recall of the material taught, and that it was enjoyable. The majority of students were very keen on recommending Microbial Pursuit to their peers. Some groups overstretched the time of the second and third sessions as they wanted to continue playing. It is worth noting that some students were interested in buying Microbial Pursuit, which at the moment is not commercialised, and in borrowing the game to use as a revision tool before their exams. Students used the section 17 of the questionnaire (table 1) to add comments such as “it was lots of fun”, “...a nice alternative to lectures and gives chance to meet other students”, “put (upload) the questions in Blackboard for exam practice”.

Microbial Pursuit was so popular that it was incorporated as a part of the curriculum in the following academic year. Despite the impossibility of running the game in person, it was adapted to an online format and, although challenging, it was an engaging experience for first-year students in need of social contact with their peers.

Learning microbiology, as with many other disciplines in higher education, can be a challenging task due to the number of new terms and concepts. Much content is given to the students in a short period of time and in order to succeed, students are asked to recall the information in their timed exams. This can generate learner fatigue resulting in the slowing down of the learning process (Kappa, 2020). To minimise the amount of material that students need to memorise and maximise the learning experience, creative solutions should be put in place and gamification is one of them. Gamification can help with the distribution of learning. Student-generated questions and answers require students, individually and in group, to identify the information from the unit material that would be relevant to generate questions (van Blerkom, 2006). Microbial Pursuit encourages students as question creators to use their higher-order thinking abilities to decide the degree of difficulty to apply to the questions and to justify their answers (Song, 2016). The difficulty that some students might encounter when generating questions is mitigated by the group activity. Microbial Pursuit facilitates learning by asking students about the material taught and it is therefore during this activity that students are encouraged to revise the unit material in both the making and the playing of the game. Once the game has been created it can be played as many times as required.

The student's fear to fail is an important element to consider in any teaching and learning settings. It is proved that providing a nurturing environment can have a positive impact on students who fear failure (Miglietti and Strange, 1998). Various factors can be considered when planning to create a positive and reduced stress classroom, for instance, activities involving the use of groups that emphasise the importance of collaboration. In the scenario of small groups working within a bigger group, students that feel more fear may feel safer because they are empowered to articulate their opinion and suggestions without the fear of being exposed to the entire group (Bledsoe and Baskin, 2014).

Microbial Pursuit allows the students, as players, to answer questions and learn the unit material through repeated attempts and failures. This "positive failure" has a different meaning in a game situation as students are in a relaxed environment, and therefore the fear to fail is no longer a threat. Moreover, it can be a motivation to attempt the next question. To help the students overcome their fear of failure, the concept of Microbial Pursuit being an educational game was reiterated during the sessions. Students were given the additional option of playing the game individually, in pairs or any other combination within the small group to minimise exposure. This option aimed to respect individual learners as well as to promote the participation of the students. It is essential that educators monitor the game, although their intervention should be minimised to avoid the imposition of an academic figure, which can lead to the change of the dynamic of the small group. Another important feature of Microbial Pursuit is that students have access to instant feedback from their peers. There are many studies reporting the benefits of feedback given immediately after a task is completed. Kulik and Kulik (1988) meta-analysis concludes that this type of feedback, opposite to delayed feedback, resulted in a better student performance when it was given in the classroom.

Microbial Pursuit can be used as a pedagogical game to teach not only Microbiology but any other subject. The versatility of the game means that it can be applied to any unit and any level. It could be used as an educational tool for outreach activities with some modifications, such as having a set of basic questions and answers ready made so younger students can play straight away. And as mentioned above, the versatility of Microbial Pursuit means that it can easily be adapted so that it can be played using an online format.

In conclusion, our pilot project shows that Microbial Pursuit is a board game that facilitates and stimulates learning in the subject of Microbiology as well as a promising method of unit revision. Playing Microbial Pursuit is also a social activity. Students not only play and learn but also meet and interact with other students, which is essential, particularly during the first year at university. Microbial Pursuit shows that games are an important pedagogical vehicle that should be used in higher education. Universities should be encouraged to embrace the concept of gamification as part of the unit content regardless of the discipline.

Acknowledgements

The author is thankful to the Bristol Institute of Learning and Teaching (BILT, University of Bristol) for funding this project and to the first year Microbiology students for their kind collaboration in conducting this project. The author is grateful to the University of Bristol Printing Service for their help and advice in the design of the cards and game board. And the author also thanks Nicolas Clark and Julian Kendell for their advice on this manuscript.

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