

GoDental! Enhancing flipped classroom experience with game-based learning

Melania Borit¹  | Lina Stangvaltaite-Mouhat² 

¹Norwegian College of Fishery Science, UiT The Arctic University of Norway, Tromsø, Norway

²Department of Clinical Dentistry, UiT The Arctic University of Norway, Tromsø, Norway

Correspondence

Melania Borit, Norwegian College of Fishery Science, UiT The Arctic University of Norway, Tromsø, Norway.
Email: melania.borit@uit.no

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Abstract

Aim: To investigate the use of game-based learning (GBL) to enhance students' experience of the flipped classroom (FC) in dental education.

Materials and Methods: Students participated in three sessions organised as FC, implemented either as conventional FC or FC augmented with the *GoDental!* game. In the pre-class phase, sessions 1 and 2 were organised as instructor-made video lectures, plus a questionnaire. These activities were supplemented with the individual development of questions and answers for the game in session 3. In the in-class phase, group and plenary discussions were used during sessions 1 and 2 and were replaced by game activities in session 3. Perceptions of session 3 compared to that of sessions 1 and 2 were explored via a questionnaire with both open-ended and Likert-scale items.

Results: Most students (29, 97%) perceived the FC session augmented with the *GoDental!* game as enjoyable. The game augmented session was perceived as more enjoyable compared to the conventional FC sessions. Students agreed that GBL augmented FC compared to conventional FC increased engagement (25, 83%), motivation (24, 83%), their integration in the social environment (23, 77%) and concentration (22, 73%), helped them learn more about the topic (24, 80%) and was a good learning method (25, 83%). There was a positive correlation between the degree of enjoyment and concentration and the feeling that the game helped them learn more about the topic.

Conclusion: Game-based learning augmented FC proved to enhance students' experience, resulting in increased enjoyment compared to the conventional FC setup. Future studies should explore whether the use of GBL in FC has the potential to increase examination performance.

KEYWORDS

board games, dental education, flipped classroom, game-based learning, serious games, student active learning

Melania Borit and Lina Stangvaltaite-Mouhat contributed equally to this study.

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1 | INTRODUCTION

1.1 | Background and aim of the study

The flipped classroom method has been widely used in higher education to foster student-centred learning.¹ This method has also been broadly implemented in undergraduate dental education with relative success.² Recent research in higher education indicates that the experience of the flipped classroom method can be enhanced by combining it with game-based learning techniques.³⁻⁵ The current study aims to investigate the use of game-based learning to enhance students' experience of the flipped classroom in undergraduate dental education, referring to the first level of Kirkpatrick's evaluation model, that is, reaction to the new experience.^{6,7} The working hypothesis was that the use of games in the flipped classroom enriches students' experience.

1.2 | Flipped classroom

Flipped classroom (FC) is defined as a set of pedagogical approaches that (a) move most information-transmission teaching out of class, (b) use class time for learning activities that are active and social, and (c) require students to complete pre- and/or post-class activities to fully benefit from in-class work.⁸ As such, FC is an instructional method that engages students in the learning process.⁹ It has been advocated that the FC method motivates students to learn and is more effective compared to only face-to-face or only online teaching.^{8,10} In dental education, a recent scoping review concluded that FC improved students' satisfaction in the majority of the studies, while its effect on academic scores, particularly for skill development, needed more research.²

Based on where they take place, two types of activities can be distinguished in the FC model of teaching and learning: out-of-class and in-class. Based on chronological order, the out-of-class activities can be further divided into pre- and post-class activities. Pre-class activities focus on concept exploration and meaning making. These activities can take a variety of forms, from instructor-made video and audio lectures to printed/online readings, quizzes and chats. This phase of FC allows self-regulated student learning. In-class activities focus on reflection, discussion and argumentation. These activities can also take various forms, from discussions to experiments and hands-on activities.¹¹

1.3 | Game-based learning

Using games in education has the potential to enhance the players' engagement and thus increase their willingness to learn, supporting the acquisition of knowledge.^{12,13} The primary characteristic of game-based learning (GBL) is that learning materials are integrated into the gameplay to stimulate motivation and problem-solving skills in learners.¹⁴ Games used in GBL activities can be commercial off-the-shelf (COTS) (and modification of these) or serious games.

The latter are games in which education (in its various forms) is the primary goal, rather than entertainment.¹⁵ These can be built by learners and/or educators/developers. Games used in GBL can be computer games or non-computer games (ie analog games), with or without computer support. Based on the game mechanism, the non-computer games can be further divided into six categories¹⁶: dice and luck, outlay games, thinking games, quiz-/communication games, role-play games and simulations, and dexterity games.

A recent rapid review regarding the impacts of serious games on healthcare and dental education¹⁷ concluded that serious games were engaging and improved learner satisfaction but stressed that these remain under-researched and under-utilised (only eight studies in dental education published between 1975 and 2016 were identified as using serious games). The limited research available indicates that while both traditional didactic methods and gaming have been successful in increasing student knowledge, the use of games generally enhances student enjoyment and may improve long-term retention of information.¹⁸ Further research evaluating educational games among health professionals or those in postgraduate training concluded that games were not superior compared to traditional teaching methods in knowledge acquisition. However, the level of reported enjoyment was higher in the GBL group.¹⁹

1.4 | Games as part of the flipped classroom model

Trying to draw on the advantages of both approaches, educators have tried to embed GBL into the FC method. However, only a few studies have explored this practice.⁵ Games can be used in any of the three parts of the FC: pre-class, in-class or post-class.¹¹ A recent scoping review of the use of GBL in FC indicated that the results presented in the articles included in their study were positive and supported the argument in favour of the efficiency of the combination of FC and GBL.⁵ In dental education, the use of FC combined with GBL seems scarce, with only two such practices identified by a recent scoping review.² These two examples used quizzes as a pre-class self-evaluation tool to assess readiness for class,^{1,20} with one of them using quizzes also as a post-class activity.²⁰ This current study diversifies the use of FC and GBL in dental education by experimenting with a game setup that includes game activities covering both pre- and in-class phases of FC. The study assesses students' perception of the GBL enhanced FC session compared to the non-GBL (or conventional) FC sessions, with particular focus on self-reported motivation of being in class, engagement, concentration/focus, feeling more integrated in the social environment of the class, and improved learning. The game that was used, that is, *GoDental!*, is described in Section 1.5.

1.5 | GoDental!

GoDental! is an adaptation for dental education of the serious game *Go'n'Fish—Fishing for Knowledge*, developed at the

Norwegian College of Fisheries Science, UiT The Arctic University of Norway.²¹ The *Go'n'Fish—Fishing for Knowledge* is a knowledge game that can be adapted to any kind of knowledge domain. For the purpose of this study, the questions of the game were formulated from the knowledge domains of dental education. In order to increase the game's visual appeal to the dental education students, a tooth was displayed in the middle of the game board instead of the water bubbles from the original design. In addition, to fit the context of dental education, the game's name was changed from *Go'n'Fish* to *GoDental!*

The *GoDental!* game is played in three consecutive phases. In phase 1 (the "make questions" phase), an individual activity that takes place outside the class, students formulate questions and answers from four knowledge domains indicated by the teacher for four categories of game questions. The teacher checks the questions and ensures that they are fit for purpose. Further, the teacher supplements these knowledge questions formulated by students with practical and fun-still-serious questions for the fifth category

of game questions. In phase 2 (the "answer questions" phase), students, divided into small groups, answer the questions in class based on throwing dice and moving pawns on a game board inspired by the popular game "Trivial Pursuit" (Figure 1). Players may bring with them any study material (eg books, notes, laptops), but they are not allowed to check this material during their turn to answer a question. The decision if the given answer is correct or not is taken by the player's group, who can check the material to search for the right answer. When decisions cannot be reached through discussion within the group, the players can ask the teacher for advice. This second phase is completed when one of the players reaches the tooth symbol in the middle of the game board. In the third phase (the "debriefing" phase), the teacher debriefs the game by reinforcing learning through discussion and reflection and avoiding false learning by providing the right answers to the questions used in phase 2.

2 | MATERIALS AND METHODS

2.1 | Participants and knowledge topics

The study was performed at UiT The Arctic University of Norway (Tromsø, Norway) in the spring semester of 2017. The sixth semester integrated Norwegian master programme students in dentistry (N = 35) and second semester Norwegian bachelor programme students in dental hygiene (N = 15) attended the same three teaching sessions as part of the teaching module in cariology. The first two sessions (sessions 1 and 2) were on the topics of de- and remineralisation of the dental hard tissues and histopathology of dental caries, respectively. The third session (session 3) was on the topic of strategies for caries control, in addition to a recap of the topics covered during the previous two sessions. The attendance was not obligatory and the number of students varied in each session. A summary of participants and knowledge topics can be found in Table 1.



FIGURE 1 Instance of playing *GoDental!*. Picture by Ørjan Garfjell.

TABLE 1 Description of the participants and knowledge topics of the three teaching sessions in dental education included in this study

Subject	Session 1	Session 2	Session 3
Set up	Conventional flipped classroom	Conventional flipped classroom	Game-based learning augmented flipped classroom
Module	Cariology	Cariology	Cariology
Students	Dental and dental hygiene students	Dental and dental hygiene students	Dental and dental hygiene students
Number of students			
Registered in the module	50 (100%)	50 (100%)	50 (100%)
Registered for class	Not applicable	Not applicable	38
Present in class	Not recorded	Not recorded	37
Filled-in evaluation form	44	28	30
Topics covered in pre-class phase	De- and remineralisation of the dental hard tissues	Histopathology of dental caries	Strategies for caries control Recap of the previous two topics
Topics covered in in-class phase	De- and remineralisation of the dental hard tissues	Histopathology of dental caries	Strategies for caries control Recap of the previous two topics

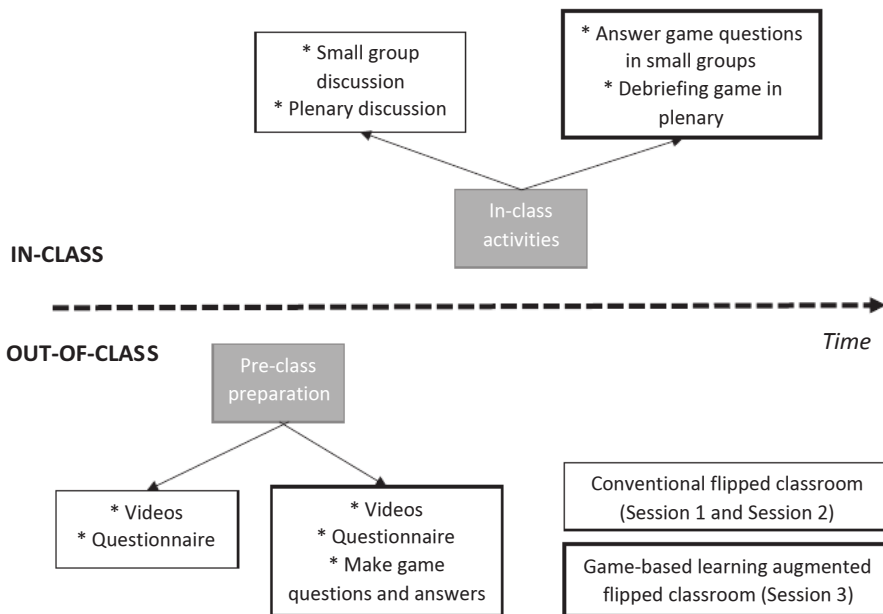


FIGURE 2 Flipped classroom set up of the three dental education sessions presented in this study (modified after 5)

2.2 | Flipped classroom setup

The FC setup for the three sessions is visualised in Figure 2. The students were not engaged in FC before.

2.2.1 | Pre-class phase

Conventional

The first two out of three sessions (sessions 1 and 2) were run in a conventional FC setup. During the pre-class phase of these sessions, three to four instructor-made video lectures (length: 3-18 minutes) were uploaded on Fronter, the digital learning management system used by the university at that time, together with a questionnaire that included up to 20 open-ended questions covering each knowledge topic that was discussed in the videos. Students were asked to watch the videos and answer the questionnaire individually.

With game-based learning

The third teaching session (session 3) was run in a GBL augmented FC setup. The students were informed that they would be playing a game during this session and that the game would start with them formulating questions and answers from the knowledge topics covered in the previous two sessions and the new topic covered in the videos and questionnaire available for the third session. Students were asked to prepare questions and answers from each of the knowledge topics and send them to the teacher, with a submission deadline of 16 days. They were extrinsically motivated by a prize for sets of minimum 10 questions and answers. Six students submitted questions and answers, all of them being sets of minimum 10 items. The teacher revised the questions and, subsequently, used them in the in-class phase together with a set of questions prepared by the teacher.

2.2.2 | In-class phase

Conventional

During the in-class phase of the first two teaching sessions, students were divided into small groups (the size depended on the total number of participants in the class and varied between three and six) to discuss the questionnaire questions (2-3 questions per group). After the discussion in small groups, which on average took 15-30 minutes, the questionnaire questions served as a basis for a plenary discussion, where each group had to cover two or three given questions. The members of the other groups were invited to supplement the answers and express their opinions. The answers were subsequently clarified by the teacher. Towards the end of each session, students were asked to fill in an anonymous paper-based feedback form where they could indicate three aspects each for what they liked and did not like during the session, evaluate their overall enjoyment (on a 5-point Likert scale), and suggest how to improve the session. Each of the two sessions took two academic hours (ie 90 minutes in total).

With game-based learning

Students were asked to register for participation in the in-class phase of the third session, in order for the teacher to know how many game sets had to be prepared. Students were extrinsically motivated to participate in this phase, as they were offered free coffee/tea and pancakes, in addition to the prizes for winning the game (one prize per player group).

During the “answer questions” phase of *GoDental!*, students were seated in the same room, in a different building than the one used during the first two teaching and learning sessions included in this study. During this phase, two teachers ensured that all players knew and understood the game rules, enforced rules and supported engagement, thus acting as game masters.²² A maximum of four students could play on one game board. The *GoDental!* objectives and rules were presented and subsequently, the students began playing

TABLE 2 Number of students (%) responding to the question “How much did you enjoy the teaching session?” on a scale from 1, meaning “not at all”, to 5, indicating that “the session was excellent”

How much did you enjoy this session: scale 1 - 5	Session 1, ^{**} N = 44 (%)	Session 2, ^{**} N = 28 (%)	Session 3 [*] N = 30 (%)
5	7 (16)	4 (15)	17 (57)
4	30 (68)	18 (64)	12 (40)
3	7 (16)	5 (18)	1 (3)
2	-	-	-
1	-	-	-
Left blank	-	1 (3)	-

Note: The number of filled-in feedback forms varied in each session.

* $P < .05$ according to Likelihood Ratio between session 1, session 2, and session 3.

** $P > .05$ according to Likelihood Ratio between session 1 and session 2

the game by rolling the dice, answering questions and moving the pawns on the game board. This phase of the game took 60 minutes. After a short break, a 20-minute long “debriefing” phase began. At the end of this phase, the students were asked to fill the paper-based feedback forms. In addition to the four questions asked in the previous two sessions, students were asked to answer questions designed to explore their perceptions of the game, in comparison with the previous two FC sessions. These questions were formulated based on previous studies on GBL (including research in dental education) that indicated that the use of games increased motivation, engagement, concentration, feeling of integration in the social environment and learning in general (eg 17,23-27). Thus, the students were asked to think of the GBL and FC session in comparison with the conventional FC sessions and indicate on a 5-point Likert scale their agreement with the given statements: playing the game increased their motivation of being in class that day, their engagement, and concentration and helped them being more focused in class, helped them feel more integrated in the social environment of the class and learn more about the knowledge topics. Furthermore, students were encouraged to express their opinion if they agreed (on the same 5-point Likert scale) that playing this type of game was a good learning method for this kind of topic; that without having played the game they would not have learned so much about the knowledge topics; and if the students would like to play more games (similar with *GoDental!* but also different kinds of games). Students were also asked to give any comments if they wished so.

2.3 | Analysis

2.3.1 | Quantitative

The answers of all students were transferred from feedback forms to an Excel file and analysed descriptively. Likelihood ratio and Kendall's Tau correlation tests in Statistical Package for the Social Sciences (SPSS) version 26.0 (IBM SPSS) were used to compare students' enjoyment in the three sessions and correlation between given statements and the degree of enjoyment in session 3. The level of significance was set at $P < .05$.

2.3.2 | Qualitative

Students' responses to the qualitative questions included in the feedback forms were analysed through coding and development of thematic topics. Coding is the process of categorising and organising information into a meaningful framework.²⁸ The term coding refers to the process of reading the data and dividing them into meaningful analytical units that are marked with a descriptive word or a category name. The coding activity was driven by the data,²⁹ which means that codes were created by the researcher while inspecting the data, in contrast to, for example, using a pre-existing set of codes that had been developed a priori to the analysis. Codes were organised under thematic topics and representative quotes were extracted.

3 | RESULTS

3.1 | Quantitative

Out of the total 50 students, 26 dental and 12 dental hygiene students registered to participate in teaching session 3, that is, the GBL augmented FC. Of these, 30 (79%) students filled-in evaluation forms after teaching session 3. The highest number of filled-in evaluation forms was received after teaching session 1, conventional FC (Table 1).

Most students (29 students; 97%) enjoyed the GBL augmented FC session (4 and 5 on a scale from 1 to 5). The GBL augmented FC session was statistically significantly more enjoyable than the conventional FC sessions 1 and 2, while there was no difference in the degree of enjoyment between conventional FC sessions 1 and 2 (Table 2). Most students agreed (4 and 5 on a scale from 1 to 5) that the GBL augmented FC session, compared to conventional FC, increased their motivation of being in class (24 students; 83%), engagement during the class (25 students; 83%), and concentration/focus during the class (22 students; 73%) and helped to be more integrated socially in class (23 students; 77%) and in learning more about the topic (24 students; 80%) (Table 3). Students agreed that this type of game was a good learning method for this kind of topic

Statement/Degree of agreement	1	2	3	4	5
Playing the game increased my motivation of being in class today	-	1 (3)	4 (14)	15 (52)	9 (31)
Playing the game increased my engagement in class today	-	-	5 (17)	12 (40)	13 (43)
Playing the game increased my concentration/ helped me being focused today	1 (3)	-	7 (23)	12 (40)	10 (33)
Playing the game helped me feeling more integrated in the social environment of the class	-	1 (3)	6 (20)	14 (47)	9 (30)
Playing the game helped me learn more about the topic	1 (3)	-	5 (17)	11 (37)	13 (43)
Playing this kind of game is a good learning method for this kind of topic	-	2 (7)	3 (10)	6 (20)	19 (63)
Without having played the game I would have not learned so much about the topic	2 (7)	3 (10)	16 (55)	4 (14)	4 (14)
I would like to play more games during the semester	-	1 (3)	2 (7)	8 (28)	18 (62)

Note: The total number of answers is different for each statement due to missing data.

(25 students; 83%) and stated that they would like to play more games similar to this one, along with other different kinds of games, during the semester (26 students; 90%) (Table 3).

The enjoyment of session 3 had a positive correlation with concentration during the class, the perception that the game helped them learn more, and the agreement that the game was a good way to learn, and they desired to play more games (Table 4). There was a strong positive correlation between the increased motivation of being in class and engagement, concentration, and the feeling that the game helped them learn more about the topic. Further, the perception that the game helped them learn more about the topic correlated positively with the increased motivation of being in class, increased concentration and enjoyment (Table 4).

3.2 | Qualitative

The qualitative results obtained from the feedback forms provided some insight into students' motivational perspectives in relation to the different activities included in the three FC sessions.

For the first session, organised as conventional FC, three main "most liked" themes were identified (with equal importance): availability of videos, the questionnaire and the teacher. The main "least liked" themes were (in descending order) as follows: difficulty of participation in discussions in plenary and the discussions went too fast.

TABLE 3 Number of students (and percentage) on agreement to the given statements when comparing game-based learning augmented flipped classroom session with conventional flipped classroom on a scale from 1 to 5, where 1 means "I do not agree at all" and 5 "I completely agree"

For the second teaching session, organised as conventional FC, three main "most liked" themes were identified (in descending order): small group discussions, visualisations and the teacher (the last two were of equal importance). The main "least liked" themes were (in descending order) as follows: too much time for group discussions and too much repetition. After this session, enthusiastic feedback was received when asked if they had any other comments: "I'm really happy about having access to videos and testing questions. Also, to discuss our answers in groups" and "All cariology sessions should be organised in this way, not only yours!" (this idea was repeated several times by different students). Several students also commented that the time for watching the videos should be included in the formal schedule of the module.

During the third session, organised as GBL augmented FC, four main themes were identified within the responses to be the "most liked" question and two main themes for the "least liked" question. The main "most liked" themes were (in descending order) as follows: fun, small group discussions that facilitated participation, food and prizes, and a lot of learning. The main "least liked" themes were (in descending order) as follows: lack of time for answering more questions and various complaints about the questions (too difficult, too simple, too similar). After this session, enthusiastic feedback was received when asked if they had any other comments: "I love this teaching method!," "It was the best repetition session I ever had!," and "You can come to school unprepared and still learn a lot."

TABLE 4 Kendall's Tau correlation coefficient and p-value between the degree of agreement to the given statements and response to the question "How much did you enjoy the teaching session?" when comparing game-based learning augmented flipped classroom session with conventional flipped classroom on a scale from 1 to 5, where 1 means "I do not agree at all"/"not at all" and 5 "I completely agree"/"the session was excellent"

Statement/Degree of agreement	Playing the game increased my engagement in class today	Playing the game increased my concentration/helped me being focused today	Playing the game helped me feeling more integrated in the social environment of the class	Playing the game helped me learn more about the topic	Playing this kind of game is a good learning method for this kind of topic	Without having played the game I would have not learned so much about the topic	I would like to play more games during the semester	How much did you enjoy the teaching session?
Playing the game increased my motivation of being in class today	0.407 0.015	0.616 <0.0001	NS	0.536 0.001	0.394 0.018	0.431 0.009	0.411 0.017	0.337 0.052
Playing the game increased my engagement in class today		0.528 0.001	NS	NS	NS	NS	0.461 0.008	NS
Playing the game increased my concentration/helped me being focused today			NS	0.474 0.004	0.470 0.004	0.310 0.058	0.689 <0.0001	0.497 0.004
Playing the game helped me feeling more integrated in the social environment of the class				NS	NS	0.435 0.008	NS	NS
Playing the game helped me learn more about the topic					0.774 <0.0001	0.376 0.023	0.542 0.002	0.429 0.013
Playing this kind of game is a good learning method for this kind of topic						0.340 0.041	0.638 <0.0001	0.582 0.001
Without having played the game I would have not learned so much about the topic							NS	NS
I would like to play more games during the semester								0.599 0.001

Abbreviation: NS, not significant.

4 | DISCUSSION

Dental education worldwide is increasingly including many student active teaching methods, with FC being only one of them. With other disciplines trying to enhance students' experience of this teaching method by including GBL elements (eg software engineering,³⁰ data science,⁴ English language³), this study explored this approach in a dental education context, with the working hypothesis that GBL enriches student experience in FC. In this study, there were statistically significantly more students who rated their enjoyment higher after the GBL augmented FC session compared to conventional FC sessions ($P < .001$). These results confirm our working hypothesis and are in line with previous studies about using GBL in FC, where higher ratings for satisfaction with the GBL augmented FC were statistically significant in the group involved in a FC with GBL compared to the group involved in conventional FC learning ($P < .001$).³

In this study, four out of five students reported that GBL augmented FC session, compared to the conventional FC sessions, increased their motivation of being in class and their engagement during the class. The motivation of being in class positively correlated with increased engagement, concentration and the perception that playing the game helped them learn more, while engagement during the class positively correlated with increased concentration and the desire to play more games during the semester. Participation in a class activity, even if passive, seems to increase learning outcomes and benefits especially for the students with lower academic performance.³¹ As one of the participants in our study explained, in the context of GBL augmented FC, "you can come to school unprepared and still learn a lot." This statement also raises the pertinent issue of student preparedness during pre-class phase and utilisation of online resources. However, it is not possible to control for student pre-class preparedness, as attending lectures (which might have been considered by the students to correspond to the pre-class phase in FC) is not mandatory in this programme, while attending seminars (which might have been considered by the students to correspond to the in-class phase in FC) is obligatory.

In this study, four out of five students reported that playing the game helped them learn more about the topic, and this correlated to increased concentration and enjoyment. This perception might have been facilitated by the *GoDental!* rules, which reinforced the achievement of the intended learning outcomes through repetition of knowledge material and reflection over it (preparing questions and answers, answering the questions, judging answers to questions, during debriefing) and through discussions (judging answers to questions, during debriefing). *GoDental!* is a quiz/communication type of game,¹⁶ and such type of games have been used previously in the context of GBL augmented FC.⁴ However, the *GoDental!* rules make the game go beyond addressing simple recollection of knowledge, as they encourage reflection and thorough group discussion. As one of the students reported during the GBL augmented FC session, "when we play, everybody needs to participate—no one can hide." In addition, *GoDental!* provided several opportunities to recap the topics in different settings (individually, in small groups,

in plenary). Working in small groups was liked in both sessions 2 and 3, but the responses from session 3 provided more insight into why this was the case. It seems that the *GoDental!* play mechanics (a) "forced" all players (ie students) to participate, not allowing anybody to "hide"; (b) facilitated discussion flow; (c) facilitated co-creation of knowledge, as players had to explain their answers to the group, and the group had to explain the "correct/wrong" verdict to the player (as one student formulated, "[I liked] the collaboration in completing each other's answers"). In total, 90% of the students expressed that they would like to play more games during the semester.

In this study, 73% of the students reported that the GBL augmented FC increased their concentration in class or helped them focus more. Increased concentration in class positively correlated with learning more about the topic, the desire to play more games during the semester, and enjoyment of the session. These results are in line with previous studies about using GBL in FC, where higher ratings for attention during a GBL augmented FC were statistically significant in the group playing the game ($P < .001$).³

Even though the feedback form was constructed based on the previous research on the use of games in higher education, the form was not validated. However, there was a statistically significant correlation between the negative control question (without having played the game I would have not learned so much about the topic) and the positive question (playing the game helped me learn more about the topic), in addition to similar correlations between these two questions with the questions about increased motivation and engagement. Thus, it is reasonable to believe that the instrument measured what was intended to be measured at a satisfactory degree. Moreover, students were asked to evaluate session 3 as a whole session (ie both pre- and in-class phases). However, it was not possible to measure how much of an emphasis the students placed on each of these phases when filling the feedback forms. Considering that the pre-class phase was implemented almost in the same manner (videos and questionnaire, and only six students formulated game questions and answers in this phase), it might be possible that students referred in their feedback only to the in-class phase of the third session (ie the "answer questions" and "debriefing" phases of the *GoDental!* game). Nevertheless, the main "most liked" aspects of session 1, videos and questionnaires, were not mentioned in the feedback form filled in after session 3. This might be because either answering questions in a game setting really took precedence or the students filled the form considering only the in-class phase of session 3 and not the entire session. Feedback questions in future studies could be more explicit about these aspects and remind the students that the third questionnaire does not refer to only the in-class phase of the game augmented FC.

Furthermore, the participation in any of the three teaching and learning sessions was not mandatory, and out of 50 registered students in the module, 44 and 28 students filled the feedback forms after attending the in-class phase of sessions 1 and 2, respectively. In addition, the number of participants in those in-class phases was not recorded, and it was not mandatory to fill the feedback forms. For session 3, 38 students registered to participate in the in-class phase,

but only 30 students filled the feedback forms. Moreover, some students who registered did not participate, and some joined the session without registering. It is possible that the students who filled the feedback forms in session 3 actually did not participate in any of the previous two sessions. Therefore, selection bias might have been introduced. Further, connecting individual students' feedback from all three sessions could allow analysis on the individual level, which may provide a deeper insight into the students' perception of GBL augmented FC compared to the conventional FC sessions. However, the setup of feedback collection in this study does not allow for following an individual student through the three sessions. Moreover, it was not possible to identify if the response was of a dental or a dental hygiene student, assuming that differences in students' backgrounds may affect their perception.

During session 3, one student who submitted 10 questions in the pre-class phase and the winners of each player group in the in-class phase were rewarded with prizes. In addition, in the in-class phase, students were offered coffee/tea and pancakes. No incentives were offered during sessions 1 and 2 (ie conventional FC). Rewards might have increased enjoyment and satisfaction, and thus, they could have influenced students' perception of session 3.³² Simultaneously, rewards could have distracted students from the learning objectives.³³ However, the perception of the participants in our study was that, compared to conventional FC, playing the game helped them learn more about the topic. It correlated to the increased motivation of being in class, increased concentration and enjoyment, thus indicating that the rewards were not perceived as distracting. Further studies could confirm this self-reported increased learning through an evaluation of examination performance, that is, other levels of Kirkpatrick's evaluation model, namely learning and results.

Even though the evidence from research shows that the FC approach is overall well perceived by teachers and learners, the objective learning outcomes of using this method are not widely investigated.^{34,35} A recent study comparing two cohorts of students exposed to conventional and FC teaching concluded that FC approach in undergraduate dental education improved immediate, but not the end of the course evaluation.¹ Our study compared GBL augmented FC with conventional FC, but only the self-reported reaction to experience of the students was evaluated, and no measurement of learning and results, such as objective learning and examination performance, was included.

Several students commented in the feedback forms filled after sessions 1 and 2 that the time for watching the videos should have been included in the formal schedule of the module. This might indicate the perceptions of increased workload in an FC setup, as reported in previous studies.³⁶

5 | CONCLUSION

Embedding GBL activities within the FC method proved to improve students' enjoyment in the context of our study. Compared

to a conventional FC setup, the GBL enhanced implementation of FC seemed to have provided more opportunities for engagement in class, motivation of being in class, and helped students learn more about the topics (all these are self-reported perceptions). These perceived benefits of GBL are in line with previous studies on the effectiveness of GBL in higher education. Based on the results of this study, it can be suggested to include GBL activities in FC, especially in the in-class phase, in order to augment the potential of this student active method for improved educational experience of the students. Further studies should explore whether the use of GBL in FC has the potential to increase examination performance.

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CONFLICT OF INTEREST


Both author have nothing to disclose.

DATA AVAILABILITY STATEMENT

Data available on request from the authors. The data that support the findings of this study are available from the corresponding author upon reasonable request.

ORCID

Melania Borit  <https://orcid.org/0000-0002-1305-8581>

Lina Stangvaltaite-Mouhat  <https://orcid.org/0000-0002-5057-8455>

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