Innovating pathology learning via Kahoot! game-based tool: a quantitative study of students` perceptions and academic performance

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ABSTRACT

Introduction:: Pathology learning for medical undergraduate students is a challenging task. Kahoot! is a mobile game-based online digital formative assessment tool that can engage students in its learning. This study is the first to assess the effect of Kahoot! use on Pathology learning outside classroom using a comparative group with assessment done at the end of the course.

Methods:: The study was carried out on the first-year Pathology students at Helwan University, Faculty of Medicine, after ending a basic Pathology course. The study is a retrospective quasi-experimental quantitative study. Academic performance of students in Pathology was compared between Kahoot! and non-Kahoot! users (55 students each). In addition, an online survey was introduced to the 55 Kahoot! user students to investigate their perceptions on it. Survey and test score data were analyzed by appropriate tests using IBM-SPSS (Statistical Package for Social Sciences). The level of significance was $P < 0.05$.

Results:: Kahoot! enhanced Pathology understanding (83.6%), retaining knowledge (87.3%), made learning fun and motivating (89.1%). Other mentioned advantages of Kahoot! were practicing for exam (40%), simple and easy to use (36.4%), competitive (18.2%), self confidence booster (10.9%), forming a comprehensive image of the lecture (9%), quick (9%), and imagining skills booster (5.5%). Mentioned disadvantages included no explanation for the answers to questions (20%). A quarter of the students stated that the time limit for the questions was short (27.3%). Kahoot! use was significantly associated with better Pathology academic performance ($P = 0.001$), and it was not related to the general academic performance of the students ($P = 0.06$). Most users (85.4%) recommended its continuous future use.

Conclusions:: The study offers an endorsement to the use of Kahoot! for gamifying formative assessment of Pathology and can provide a basis for the design of an online Kahoot! -based continuous formative assessment plans implemented outside-classroom in the Pathology curricula.

1. Introduction

Pathology learning requires continuous training of cognitive skills as well as learning large sum of knowledge about diseases [1]. Including continuous formative assessment plans in the curriculum permits learners to demonstrate their knowledge acquisition and skills` development. Learners receive support and feedback during the process to promote their improvement, hence enhances their learning [2]. Finding methods that engage and motivate students to be continuously evaluated and seeking improvement is needed. [3]

Mobile game-based learning (MGBL) strategies create playing-learning environments which combine both mobile learning (using mobile devices) with game-based learning theories (that use elements of games in learning) leading to more effective acquisition of knowledge [4,5]. Mobile learning allows flexible close-to-hands learning, while game-based learning creates learning environments that follow the bases for the brain-based learning model [6]. They are pleasant, learner-centered, challenging students` cognitive skills, and promoting effective learning. [4,5] This makes MGBL a good choice to be included as a learning strategy in higher education especially in the medical education field. However, the use of mobile game-based learning is still limited in higher education [7].

Kahoot! is a formative assessment freely available online tool that is based on the concept of MGBL. Kahoot! creates a competitive environment through providing time limits and scoring for its quizzes. It was launched in 2013, [8] by Mobitroll; a collaboration between the Norwegian University of Science and Technology with the British company We Are Human. [9,10] Kahoot! is supported by mobile devices and it can be accessed on any appliance that has an internet signal with no location limits. It can be

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Supplemental data for this article can be accessed here

utilized inside or outside the classroom for individual students` asynchronous practice or synchronous students` challenges. [8,11–13]

Quizzes can be created freely on the platform. The instructor selects "create quiz," then the type of the question he/she plans to create (MCQ, or true/false). Then the instructor writes the question in the proper place and chooses the desired allowed time for each question. The platform asks the instructor to mark the correct answer to be presented automatically and instantly to the students as a feedback after they answer the question. The instructor continues to add questions to the created quiz then publishes it. [12,13]

To share a quiz, Kahoot! tool auto-generates a sharable code or link for the instructors. Students can access the game by using the Kahoot! application or by browsing the website via a laptop or smartphone. They enter the shared code or browse the shared link and sign up/in and the Kahoot! game starts. The students collect points based on their speed in offering correct answers. [8,14]

Quizzes can be assigned either as an individual practicing tool where each student practices asynchronously on the quiz any time they want with no time limits, or as challenges between students that can be held live inside the classroom or outside the classroom as time-bound challenges. Scores are offered for all participating students as well as the instructor. for the challenges, a winner`s list is generated automatically by the platform based on students` scores & time spent in the quiz. [12,13]

Game elements present in Kahoot! quizzes include stimulating music, colorful animations, and a countdown for each question which maintain participants engagement and creates a sense of competition. Kahoot! creates a bar graph for each quiz that shows how many participants chose each of the answers provided, which gives feedback for both students and instructors [15]. Literature reported some advantages as well as challenges that faced Kahoot! student-users in varying educational settings. [16]

The pilot study by Neureiter et al. (2020) is the only research done evaluating the use of Kahoot! MGBL tool in Pathology learning [17]. It evaluated the general students` perception on the use of Kahoot! and revealed good acceptance of it. It also evaluated the academic performance through pre and post kahoot tests. However, no comparative group was included in the study to evaluate if the increased performance is real compared to a non kahoot!- using group. Moreover, Kahoot! implementation as well as the pre and post tests were all done in the same teaching session which makes the evaluation based on the short-term memory of students retaining the acquired knowledge in the classroom.

Learning is a long-duration process. To assess learning retention, students` performance is evaluated during learning itself (i.e. on a short learning-time frame) [18] as what was done by Neureiter et al. [17], and also during testing after learning is completed usually after a delay (i.e. on a longer learning-time frame) [18].

So, we aimed at assessing learning of students on a more distant learning-time frame. Our research is the first in literature that investigates the effect of using Kahoot! outside classroom in Pathology learning (i.e. students` perception, and academic performance) using a comparative group with assessment done at the end of the course.

2. Materials and methods

2.1. The setting

The study was carried out on first-year Pathology medical school students at Faculty of Medicine, Helwan University. The school adopts the SPICES curriculum [19], which has two phases – Phase I consists of Year 1 and 2 (pre-clinical basic medical sciences phase) and Phase II consists of Year 3 to 5 (clinical phase).

Pathology is a part of the multidisciplinary integrated curriculum of the 1st year, starting from the first module. The Pathology course consisted of 10 lectures and 4 laboratory sessions that were all taught face to face in the faculty campus. It took place between September 2019 and February 2020. The course covered most of the basic pathological principles of diseases (adaptation, cell injury, inflammation, healing, repair, and circulatory disturbances).

2.2. The tool used

Kahoot! Platform was used to create outside classroom Kahoot! quizzes after each lecture in the course. Each quiz included 10–25 multiple choice (MCQ) and true/false questions. Invitations` links for each quiz were created by the instructor and shared on the students' learning management system. Students needed to press on the shared link to be able to participate in each quiz. Students can participate in each quiz in a time-bound individual synchronous challenge, or in asynchronous individual practicing form according to their preferences.

For students who chose to enter the challenges, the first 3 winners for each quiz were celebrated by the platform by displaying the names in descending order at the end of each challenge. Winners were also honored by announcing them on the class' learning management system (LMS) as the "Kahoot! challenge champions in Pathology." At the end of the course, the 1st top winner (with highest total Kahoot! scores) was awarded the Kahoot! champion cup of the course in a live celebration attended by all students in the lecture hall.

2.3. Sample

This study was conducted on a cohort of 110 first-year preclinical medical students with age range between 17 and 19 years. Convenience sampling was done; both Kahoot! users and nonusers were recruited according to their agreement to participate. They were allowed to choose freely whether to use or not to use the Kahoot! in their learning. One hundred ten students participated. They were from different high school educational system backgrounds. Fifty-five students joined each group (Kahoot! users` group versus nonusers). No randomization was done for the student groups. Participants' characters are shown in Table 1

2.4. Study design and implementation

This study employed a retrospective quasi-experimental design. After the Pathology course was finished, the academic performance of students of

Table 1. Demographic data of study participants.

Character	Frequency	%
Gender		
Male	54	49.1
Female	56	50.9
High school background		
Egyptian high-school education (Thanaweya Amma)	60	54.5
IGCSE, American diploma, & Stem high school	11	9.9
Arabic non-Egyptian & other international certificates	39	35.5
Academic performance (Grade)		
A	62	56.4
B	20	18.2
C	13	11.8
D	6	5.5
F	0	0
Postponed previous exams	9	8.2
Use Kahoot!		
Yes	55	50.0
No	55	50.0
Previous experience using Kahoot!		
Yes	14	12.7
No	96	87.3

both groups study (Kahoot! tool users versus non-Kahoot! users) was done by an online comprehensive final formative test carried out at the end of the Pathology course on the class' LMS. An online survey was also introduced at the end of the course to the Kahoot!-users` group to assess their perception of the tool (Figure 1).

Google Forms tool was utilized to introduce the survey. Students were invited to participate in the online survey shared on their LMS. The survey consisted of a descriptive 21 item questionnaire describing the students` perceived impact of implementing Kahoot! tool during basic Pathology learning (Supplementary #1). Some questions were adapted from the questionnaire used by Ismail & Mohammad (2017) on their study titled "Kahoot: a promising tool for formative assessment in medical education." [2] Responses were on a five-point Likert scale with 1 (strongly disagree) to 5 (strongly agree) [20]. Adding open-ended written feedback was optional for which breakdown analysis was done to analyze the written data. Before dissemination to students, the survey was sent to two experts in medical education for revision and validation, and slight modifications were done based on their opinions. The final-version survey questions were internally consistent with a calculated Cronbach`s alpha of 0.89.

3. Data collection

The survey data and students` test scores were collected on Excel spreadsheets.

3.1. Data analysis

Survey and test score data were analyzed using IBM-SPSS (Statistical Package for Social Sciences) Version 21.0. A Chi-square test was used to
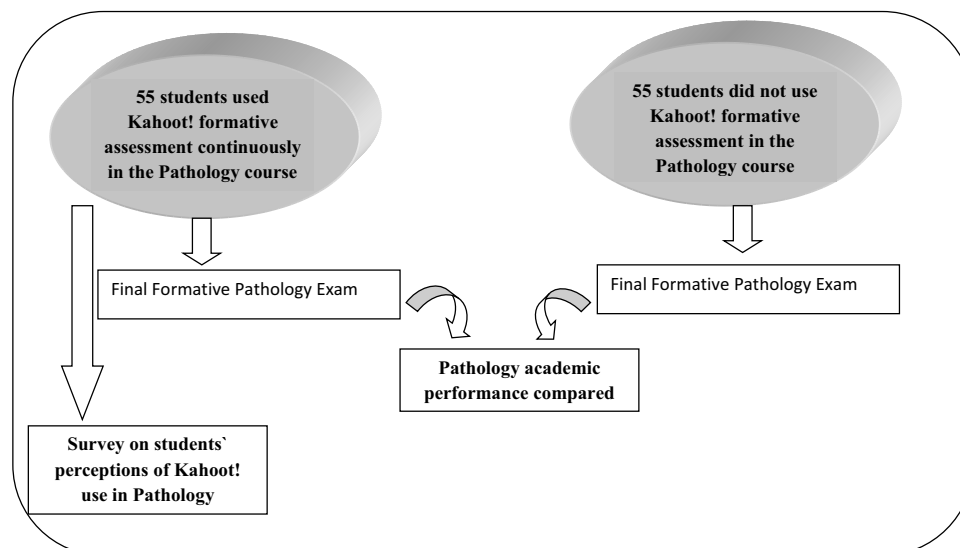

Figure 1. A diagram illustrates the study design

compare qualitative variables, and t-tests were used to compare quantitative variables. Z-tests were used to compare proportions. Cronbach alpha test was used to analyze internal consistency of the survey items and a value > 0.7 is considered internally consistent. The level of significance was $P < 0.05$.

3.2. Ethical approval

The study complied with the Helwan University Ethics Committee Guidelines for research with humans and has been approved by the Helwan Medical School Ethics committee (Serial number: 15–2019), organized and operated according to the declaration of Helsinki. Consent of participation was obtained from all participants prior to their participation in the study as well as for publication of the results.

4. Results

4.1. Analysis of criteria of Kahoot! tool users

Female students who used the Kahoot! tool were significantly higher than male students (P 0.004). The type of high school education system also significantly affected it (P 0.000). Z tests showed a high difference between students of stem, American diploma, and IGCSE systems who all used Kahoot!, compared to students of Arabic and other international high school systems who used it less. Only 8.2% of students used Kahoot! and had a previous experience on using it (n = 9). Previous Kahoot! use did not significantly affect its re-use in Pathology (P 0.3). (Table 2)

4.2. Analysis of the academic performance of students using Kahoot!

Regarding the Pathology academic performance, scores of students who used Kahoot! tool were significantly higher (P 0.001) in the comprehensive formative Pathology test held at the end of the course (mean 15.04, SD ±6.15) compared to those who did not (mean = 11.00, SD ±5.82).

The general academic performance of the students was assessed by participants` grades in the end module summative integrated exam held during the research duration. More than half of Kahoot! users had grade A compared to one third of nonusers. Also, 20% of users had grade B compared to 10% in nonuser students. However, the difference was not statistically significant but points to a better academic performance in Kahoot users. (Table 2)

Table 2. Criteria of Kahoot! versus non Kahoot! users among participants of the study.

Character		Total	Kahoot use Yes	No	P
Gender					0.004
Male	No.	54	19	35	
	%	49.1	17.3	31.8	
Female	No.	56	36	20	
	%	50.9	32.7	18.2	
High school background					0.000
Egyptian high-school education (Thanaweya Amma)	No.	60	35	25	
	%	54.5	31.8	22.7	
IGCSE, American diploma, & Stem	No.	11	11	0	
	%	9.9	9.9	0.0	
Arabic non-Egyptian & other international certificates	No.	39	9	30	
	%	35.5	8.2	27.3	
Academic performance (Grade)					0.06
A	No.	62	37	25	
	%	56.4	33.6	22.7	
B	No.	20	10	10	
	%	18.2	9.1	9.1	
C	No.	13	3	10	
	%	11.8	2.7	9.1	
D	No.	6	1	5	
	%	5.5	0.9	4.5	
Postponed exams	No.	9	4	5	
	%	8.2	3.6	4.5	
Previous experience using Kahoot!					P = 0.3
Yes	No.	14	9	5	
	%	12.7	8.2	4.5	
No	No.	96	46	50	
	%	87.3	41.8	45.5	
Total	No.	110	55	55	
	%	100.0	50.0	50.0	

No.:The number

4.3. Analysis of students` preferences and perceptions of using Kahoot! as a formative assessment tool

Of the 55 students who used Kahoot! tool; 72.7% (n = 40) preferred the individual practicing asynchronous quizzes over the synchronous students` challenges (n = 15, 27.3%).

Overall, the majority of students perceived Kahoot! as a reason for increasing their interest in Pathology studying (n = 51, 92.7%), beneficial for its learning (n = 48, 77.3%), and enhancer for its understanding (n = 44, 83.6%). The majority (85.4%) recommended its continuous future use in learning Pathology (n = 47). This is explained by the following positive extracted results:

Over 90% of students (n = 50, 90.9%) considered it helpful to focus on the subject details, retain knowledge (n = 48, 87.3%), and correct misconceptions on the subject (n = 45, 81.8%), as well as being an effective method for reflective learning (n = 46, 83.7%). The majority (89.1%) of users perceived Kahoot! as an effective method to provide feedback (n = 49). It motivated users for learning (n = 45, 81.9%), and made their learning experience fun (n = 49, 89.1%). (Table 3, Figure 2)

Table 3. Students` perceptions of Kahoot! use.

Survey Item	Rank*									
	1		2		3		4		5	
	No.	%	No.	%	No.	%	No.	%	No.	%
Kahoot! quizzes benefit me in learning Pathology	0	0	0	0	7	12.7	16	29.1	32	58.2
Kahoot! motivates me to learn Pathology	0	0	1	1.8	9	16.4	20	36.4	25	45.5
Kahoot! helps me to focus on the details of the subject	0	0	2	3.6	3	5.5	9	16.4	41	74.5
Kahoot! helps to retain my knowledge	0	0	2	3.6	5	9.1	14	25.5	34	61.8
Kahoot! is an effective method to provide feedback	0	0	1	1.8	5	9.1	20	36.4	29	52.7
Learning with Kahoot! is fun	1	1.8	0	0	5	9.1	13	23.6	36	65.5
Kahoot! is an effective method for reflective learning	0	0	1	1.8	8	14.5	15	27.3	31	56.4
Kahoot! is an effective method to correct my misconceptions on the subject	0	0	0	0	10	18.2	19	34.5	26	47.3
Kahoot! enhances my understanding of the subject	1	1.8	2	3.6	6	10.9	19	34.5	27	49.1

*No.: The number; Rank: 1 (strongly disagree), 2 (disagree), 3(neutral), 4(agree), 5 (strongly agree). 4 and 5 are considered positive results
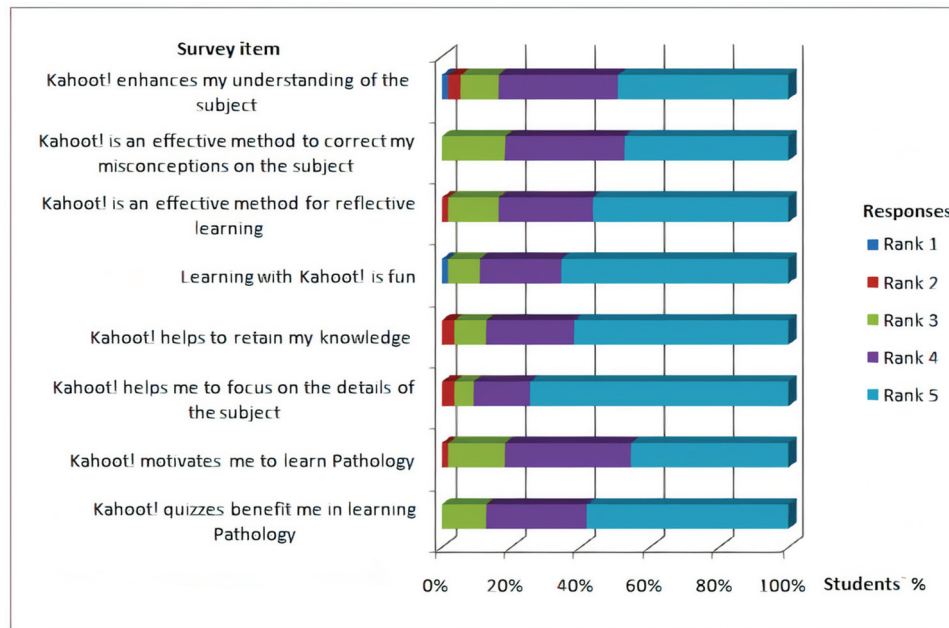
Figure 2. A chart illustratesstudents` perceptions of Kahoot! use

Table 4. Students` perception of the level of cognition assessed by Kahoot! use.

Skill assessed by Kahoot!	Yes		No	
	No.	%	No.	%
Problem solving	38	69.1	17	30.9
Interpretation of scientific information	38	69.1	17	30.9
Evaluation of a given pathological information	34	61.8	21	38.2
Application on new situations	51	92.7	4	7.3

Kahoot! use is considered a useful tool for assessment of higher cognitive skills by majority of users; analysis (problem solving skills) (n = 38, 69.1%), evaluation skills (n = 34, 61.8%), application on new situations (n = 51, 92.7%), and understanding (interpretation skills) (n = 38, 69.1%). (Table 4, Figure 3)

Other mentioned advantages of Kahoot! in a descending order were practicing for exam (n = 22, 40%), simple and easy to use (n = 20, 36.4%), competitive (n = 10, 18.2%), self confidence booster (n = 6, 10.9%), forming a comprehensive image of the lecture (n = 5, 9%), quick (n = 5, 9%), and imagining skills booster (n = 3, 5.5%). Mentioned disadvantages included no explanation for the answers to questions

(n = 11, 20%). A quarter of the students stated that the time limit for the questions was short (n = 15, 27.3%).

5. Discussion

Our study results showed that using Kahoot! as a mobile game-based tool in learning Pathology was well perceived by students as a learning booster and engager, and that it enhanced students` academic performance in this medical science.

Medical students in the pre-clinical years of an integrated curriculum might be upset by the amount of knowledge they need to gain, with educators are often faced with the challenging responsibility of teaching a large volume of content in a short time frame [21]. The use of innovative methods in basic science teaching is mandatory nowadays to tackle this problem while keeping up with the new generation of learners. Studies have suggested that today's students tend to stay more engaged in the educational activities with technology involved. [22,23]
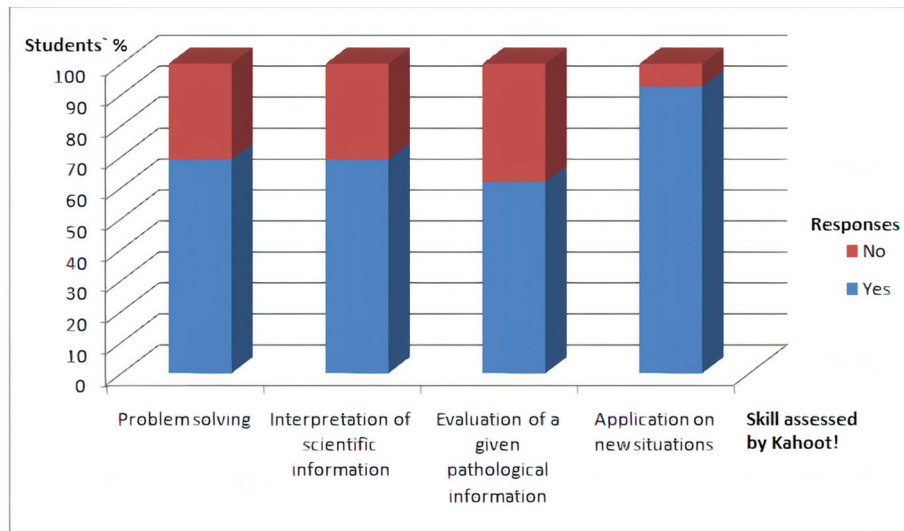
Figure 3. A chart illustratesstudents` perception of the level of cognition assessed by Kahoot! use

Pathology as a basic medical science linking academic knowledge to clinical cases has always been considered challenging, as students are required to understand, interpret, apply, evaluate, problem solve and memorize a large sum of information about the human body. Innovations in teaching Pathology such as virtual microscopy, public engagement, and podcasts have been tried over the past few years. [24,25]

Games are helpful to obtain high academic performance, motivation, and improvement of classroom dynamics. Incorporating games in learning started to expand in higher education. Games may be used to overcome some limitations of the traditional face-to-face teaching [15]. Besides, the game-based learning theory implies that commitment in performing a task while playing stimulates the higher functions of the brain for active learning; this increases knowledge retention by helping the brain transform information from short to long-term memory [26].

Integrating a game-based tool in learning can allow students to revise and apply what they have learned in an interactive, fun, and competitive way [11]. Enhancing game-based learning can enhance medical students` engagement with Pathology and the findings of our study on like Kahoot! use are consistent with the literature on digital games [27]. Learning methods and platforms that incorporate gamification as Web-based programs, mobile applications, and virtual patient simulations have proven successful in engaging students in learning activities.

To elicit students' interest and develop their skills, continuous formative assessments in the form of online competitions using Kahoot! were carried out in this study. Our first-year preclinical medical students were challenged with one new Kahoot! competition after each lecture over a basic Pathology course to boost their learning by permitting the immediate application of their acquired new knowledge [28].

Students with different high school types and educational systems enrolled in our study. Analyzing the criteria of students who chose to use the Kahoot! tool in their learning; there was a significant association between the high school type of students and their use of the Kahoot! tool in the faculty with all students of stem, American diploma, and IGCSE high school systems that were enrolled in our study chose to use the Kahoot!. Nearly half the students of the Egyptian high-school education (Thanaweyya Amma) that were enrolled in the study chose to use it. Two thirds of the students of the Arabic non-Egyptian & other international certificate types that were enrolled in our study chose not to use it. So, the type of learning received in high school impacts students` choices of learning methods in higher education. However, participation in interactive learning and providing feedback in higher education institutions is not limited to a certain background [29]. More encouragement to try gamification in learning and attention should be given to national students as well as students of other Arabic high school backgrounds being the least using group.

Regarding the gender, female users in our study significantly exceeded males. Females were also found to favor flexible and interactive e-learning methods by other researchers [30].

The majority of Kahoot! user students involved in the study never used this application before and yet 36% of Kahoot! user students reported it is easy to use. This might indicate that students are willing to try new educational tools offered to improve their learning experience.

The majority (72%) of Kahoot! users preferred the individual asynchronous practicing quizzes over the synchronous individual challenges. Students need to set their pace for training. They are just starting their first medical education year and might not be used to competitions. Students need to be encouraged and motivated.

Using the mobile game-based learning strategies was reported to have good impact in higher education. Troussas *et al.* (2020) showed higher potential for students to achieve their learning goals with higher efficiency and satisfaction [7]. Our study showed similar results; the majority of Kahoot! users appreciated it as a tool for formative assessment. They recognized it as beneficial, facilitating and enhancing learning, and increasing their interest in Pathology studying. Moreover, they recommended its continuous future use in learning Pathology. They found it helpful to focus on and retain scientific details, with correction of misconception. Similar results were also obtained by former studies on other basic medical sciences [31,32].

Tóth *et al.* [13] found that lack of engagement in activities is associated with significantly lower performance while Chang & Hwang (2019) showed that MGBL affects positively the learning outcomes by the offered pleasant user-interface and the enhanced students` enjoyment while interacting with the platform [33]. Using Kahoot! was associated with good academic performance in Pathology that was not related to the general academic performance of the students. Scores obtained in the comprehensive formative Pathology exam showed significantly higher performance of Kahoot! tool users. Felszeghy *et al.* [8] also reported higher academic performance in the Kahoot! user students in Histology, however, it was not statistically significant. Our results are encouraging and support the use of this tool in the somewhat difficult-nature subject.

Mobile game-based learning can develop students` skills during their learning by following specific strategies [34]. Critical thinking, problem-solving, reflectivity, analysis, and contextual learning are cognitive competencies needed for an efficient graduate medical student, and their skills can be developed starting from preclinical years [35]. Students agreed that they could practice questions that stimulated their higher cognitive functions on Kahoot!. Kahoot! application allows the creation of various types of questions including those that can challenge and stimulate students` higher cognitive skills like problem-solving questions. Learning via Kahoot! can create a brain-based learning environment with potentiation of the learning outcomes [36]. Therefore, not only adding a new educational tool is enough, but we recommend choosing how to use it according to the nature of the subject/discipline and the target outcomes is an important factor.

This study confirms the positive effect on academic performance found by Neureiter et al. (2020) in Pathology learning. [17] While Neureiter et al. used Kahoot! tool in the classroom immediately after the lecture; our students used the tool outside classroom which makes Kahoot! tool beneficial on the intermediate and long-term memory levels. Our study also used a comparative group to confirm the positive effect of Kahoot! which was not used by Neureiter et al. (2020).

Students considered Kahoot! more competitive and challenging in the open-ended questions of the survey; described it as fun, non-boring, and play-like with attractive better design. Some reported that it boosted their self-confidence related to answering exams. However, nearly quarter had concerns about the time limit for each question in the quizzes. Challenges reported in the literature that faced Kahoot! tool implementation include technical problems, stress related to not having enough time to answer, and fear of losing. [16] Challenges to incorporate new technological means should be considered before applying any tool, however, this should not restrain its trial. The time limit for each question during the quiz design should be taken into consideration and prolonged a little bit than that considered "suitable" by the instructor to allow students for thinking and training. We recommend that instructors might add a 2nd version for each quiz to the platform with the considered "suitable" shorter time assigned for the questions for a 2nd phase training. This goes with the recent trends for the need of creation of more personalized learning experiences for students in which learning is tailored to students` criteria [36,37]. Future studies need to investigate the impact of designing more personalized Kahoot! quizzes on Pathology learning.

Study limitations include small number of participants, being implemented only in a basic Pathology course with no systemic pathology included and being carried out on one batch and in one institution. Further studies on a wider scale of students should be done.

6. Conclusion

This study assessed the criteria and effects of using Kahoot! as an online game-based tool for continuous outside-classroom formative assessment, on undergraduate preclinical students' engagement and satisfaction while learning a medical Pathology course. The results offer an endorsement to the use of Kahoot! gamification in Pathology learning and can provide a basis for designing a Kahoot! -based formative assessment plans in Pathology curricula. The additional competition aspect of this tool added a supplementary educational value. Besides, through its flexible question design, it offered the opportunity to stimulate and train students` higher cognitive skills needed for future practitioners` competency.

Disclosure statement

Funding

Notes on contributors

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Data availability

The datasets generated and analysed during the current study are available at the corresponding author upon request.

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