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Design, implementation, and evaluation of a learning web application for oral and maxillofacial pathology

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ABSTRACT

Background: Studying pathology is not a fascinating subject for many students. Today, novel educational methods have received attention worldwide. This study aimed to design an oral and maxillofacial pathology learning application and evaluate its effectiveness on dental students' knowledge of the Isfahan dental faculty.

Materials and Methods: In this experimental study, after designing a web application, including an oral pathology context (PathoGAME), its effectiveness on 112 junior dental students' knowledge was investigated in 2022. After introducing the application, students were motivated to use the app for learning oral pathology. They were then examined in the midterm and final examinations. Subsequently, their scores on the questions related to the application's contents were compared with the scores of other questions. Finally, students' satisfaction with the application was evaluated. The data were analyzed using SPSS software and paired *t*-tests, Pearson's tests, and analysis of variance.

Results: In the midterm examination, there was no significant difference between the mean score of questions related or unrelated to the application's content among those who had used the application. Furthermore, the mean scores of the related questions for the application users and those who did not, were not significantly different ($P = 0.5$). However, on the final examination, the mean score for questions related to the application was significantly greater for students who used the application than for those who did not ($P = 0.03$).

Conclusion: Overall, novel educational methods, such as this application, were beneficial for improving students' understanding of pathology. The users' satisfaction was high in utilizing this application, indicating the application's success and confirming its feasibility.

Key Words: Cellphone application, dental student, learning, oral pathology

INTRODUCTION

Oral diseases are significant health problems at the global level and have both high prevalence and adverse effects on individuals and societies. In general, more than 3.5 billion people around the world suffer from oral diseases.[1] These lesions are among the most challenging oral conditions in public health.[2] Since they diminish health-related quality of life by causing local discomfort and pain, as well as

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interfering with speaking, swallowing, chewing, and maintaining oral hygiene.[3] These disorders can be chronic and progressive, developing in childhood and continuing into adulthood.[1]

The oral cavity must be examined for malignant changes through exact clinical examinations and routine screening. These changes should be easily detected in the early stages to lead to more effective disease management. Despite easy access to the oral cavity for examinations, oral cancer remains a disease with high mortality. Early diagnosis and treatment decrease patient morbidity and mortality; however, most oral cancers are diagnosed at late stages, even in developed countries.[4] When these lesions occur and are diagnosed at early stages, simple treatment is needed, and subsequently, the defects and disfigurement are minimized.[5]

Patients with oral lesions are often examined by general dentists for the first time; therefore, general dentists play a vital role in diagnosing oral cancers in the early stages.[6]

Oral pathology is a specialty of dentistry that addresses the diagnosis and management of oral and maxillofacial lesions. The knowledge of pathology bridges the gap between basic and clinical dental science, which is essential in training students to correctly diagnose the cause and mechanisms of oral diseases.[7] This knowledge is critical for diagnosing and curing oral mucosa lesions, including benign, premalignant, and malignant lesions.[8]

According to medical science professors and students, this knowledge is considered one of the most challenging subjects in the educational curriculum. Moreover, it is neglected by many dentists because they are not ordinarily involved with oral pathology.[9] The nature of pathology knowledge, insufficient experience in diagnosing oral lesions, and some teaching methods, such as lecture-based methods, are the causes of the inherent challenges of this knowledge for medical students. According to medical students' experiences, the main reasons for the difficulty of studying pathology are the extensive terminology of lesions, the large volume of information materials, and the inadequate time allocated to this subject in the educational curriculum.[10,11]

Considering the technological advances and changes in the digital world in recent decades, the need to change traditional learning methods or to accompany novel methods is expected. In this regard, learning applications are suggested as effective educational tools that engage students in purposeful, entertaining, and motivating activities in a safe environment. In addition, it provides a platform where social interaction and bonding among students are promoted, thus increasing students' connection with the educational environment and the desired subject.[12] Web-based applications are known as teaching methods for multimedia.[13] Traditional tutorials are teacher-centered, presenting a summary of concepts. Sometimes, these methods are tedious and less practical; students' participation in these methods is inadequate, and critical thinking or the application of the acquired knowledge might be ignored.[14] However, applications, as educational tools, include innovative, challenging, and student-oriented methods. Combining digital educational applications with current medical science is a newly designed method for students in healthcare fields.[15] As an educational strategy, these applications have the potential to improve students' performance by improving knowledge, self-learning skills, and attitudes.[16]

An increase in problem-solving skills and critical thinking has been observed through the use of these kinds of applications.[17] These applications provide an entertaining, educational environment in which students are faced with various questions.[18] With this method, students can design hypotheses and provide solutions where they can learn from their errors without fatal results for actual patients.[19] Moreover, these applications make learning enjoyable, challenging, and stimulating, and provide the opportunity for students to play constantly in all places.[20]

Similar studies have been conducted on application design and development. In this regard, Kanthan and Senger investigated the effect of the application on learning pathology in students in 2011. In this study, the students' pathology course grades increased significantly with the use of game-based application training. Moreover, students' satisfaction, individual learning, and stress reduction were observed.[21]

Janssen *et al*. discussed the effect of the application on learning anatomy and histology in students. Approximately 89% of individuals were satisfied with this new method, 93% found it challenging, and 73% reported the desire to carry on learning with this

application. Finally, the study findings indicated that this method was efficacious in acquiring anatomy knowledge and attracting students.[22]

In another study, Gudadappanavar *et al*. investigated the effect of a game-based application on students' pharmacology course learning and reported students' higher grades using the application. Furthermore, students' feedback and interest in this group were greater, considering this method unique, active, and entertaining.[15]

Tsopra *et al*. designed an application to train students on the use of antibiotics. Students considered this method attractive, practical, enjoyable, and appropriate for learning. Nearly 87% to 89% of individuals considered it inspiring, and 96% were engrossed by this game.[18]

By designing an educational application to facilitate learning neurology, Anton Raskurazhev *et al*. achieved significant results by comparing scores before and after using the application. They reported significant positive results while using this method and referred to educational games as an appropriate choice for medical education; these games were promotable, cost-effective, and influential for increasing concern and motivation in medical students.[23]

Despite the effectiveness of the application in the above studies, in the study by Jesse Courtier *et al*., which was conducted to compare the effectiveness of training radiology through traditional and game-based methods, the findings showed that the students in the traditional training group obtained higher scores than those in the other group. Moreover, the understanding of the information material and their recall were reported to be greater in the traditional methods group. However, no significant difference was observed in the students' interest in radiology knowledge between the two groups.[24]

Due to the global prevalence of these oral lesions and their impact on individuals' quality of life, the significance of pathology knowledge for early diagnosis of these lesions, and students' indifference to studying and learning pathology, it is necessary to utilize novel learning approaches. Therefore, considering the contradictory findings about the impact of educational applications on students' learning and the limitations of this method in learning oral pathology in Iran and abroad, this study aimed to design and develop an application for teaching oral pathology to dental students to promote the education, diagnosis, and treatment of pathological lesions.

MATERIALS AND METHODS

The present quasi-experimental study was conducted in 2022–2023 at the Dentistry Faculty of Isfahan University of Medical Sciences. An application was designed for 112 3rd-year dental students to learn oral pathology.

The protocol was approved with the number IR.MUI.RESEARCH.REC.1401.171 by the Ethics and Research Committee of Isfahan University of Medical Sciences.

Design of the application

In the design of this application, called PathoGAME, three exercises were assigned to each lesion separately. The questions designed in this application are in English. The design and completion of this application were performed within 4 months by a software engineering specialist.

Before accessing the exercises, users are prompted to sign in through the sign-in page, which ensures secure and personalized access to the application [Figure 1]. After signing in, the first exercise is available to the user. [Figure 1].

After completing the first exercise, the second and third exercises are activated. In addition, the application design allows the user to access more exercises by choosing the fourth exercise. Five separate stages are considered for each exercise [Figure 2].

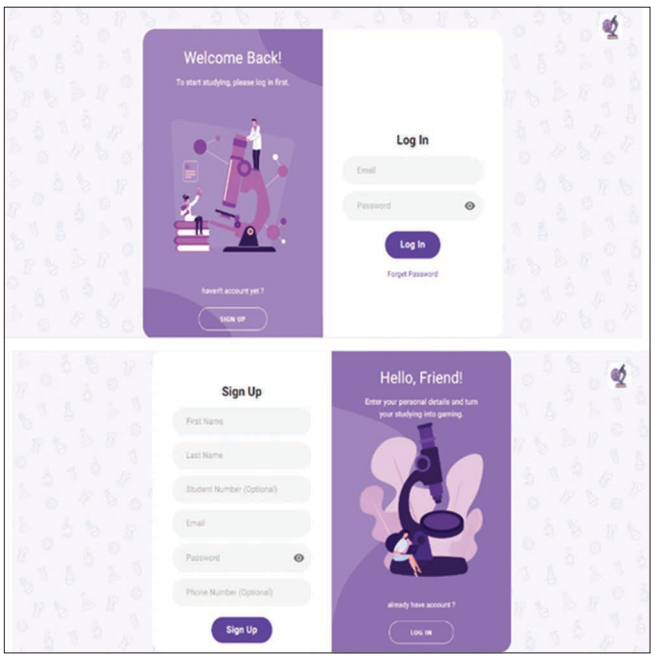

Figure 1: Sign-in page of the application.

23 The first stage consists of 4-choice questions in which the user is asked several questions related to the type of lesion [Figure 3a]. Afterward, the user's correct and incorrect answers are given in green and red, respectively, along with feedback to guide the user to study the relevant section displayed in the reference book (Oral and Maxillofacial Pathology Neville).

In the second stage, some true/false questions related to the type of lesion are displayed to the user [Figure 3b]. Finally, the correct and incorrect answers are displayed in green and red, respectively, along with feedback to guide the user to study the relevant section in the book.

The user is asked several short-answer questions in the third stage [Figure 3c].

In the fourth stage, depending on the lesion type, one or two cases are presented, and the patient's medical history, including clinical information, histopathology view or radiographic image, and photography related to the lesion type, are displayed [Figure 3d and e]. Then, the user is asked questions about differential diagnoses, possible final diagnoses, and management. The correct answer is displayed to the user on completion.

In the fifth step, the general statistics of the test, including a general explanation, the number of questions asked, and the percentage of correct questions, are presented to the user [Figure 3 f].

After completing each exercise, users can have an overview of the exercises, including the stages, questions, and their answers, and the feedback for each question by selecting that exercise again. In the first, second, and third stages, there is a possibility for the user to skip the question. The unanswered or

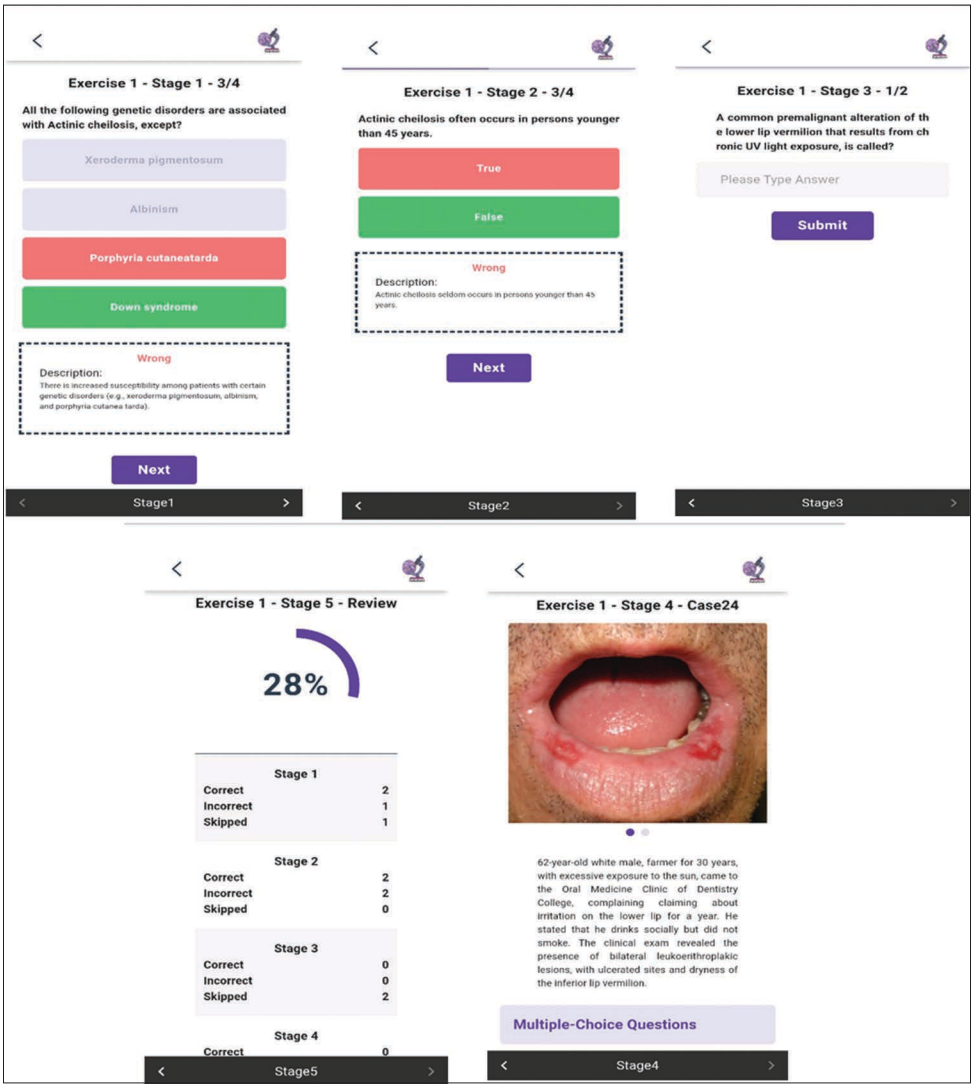

Figure 2: Stages of application using mobile device

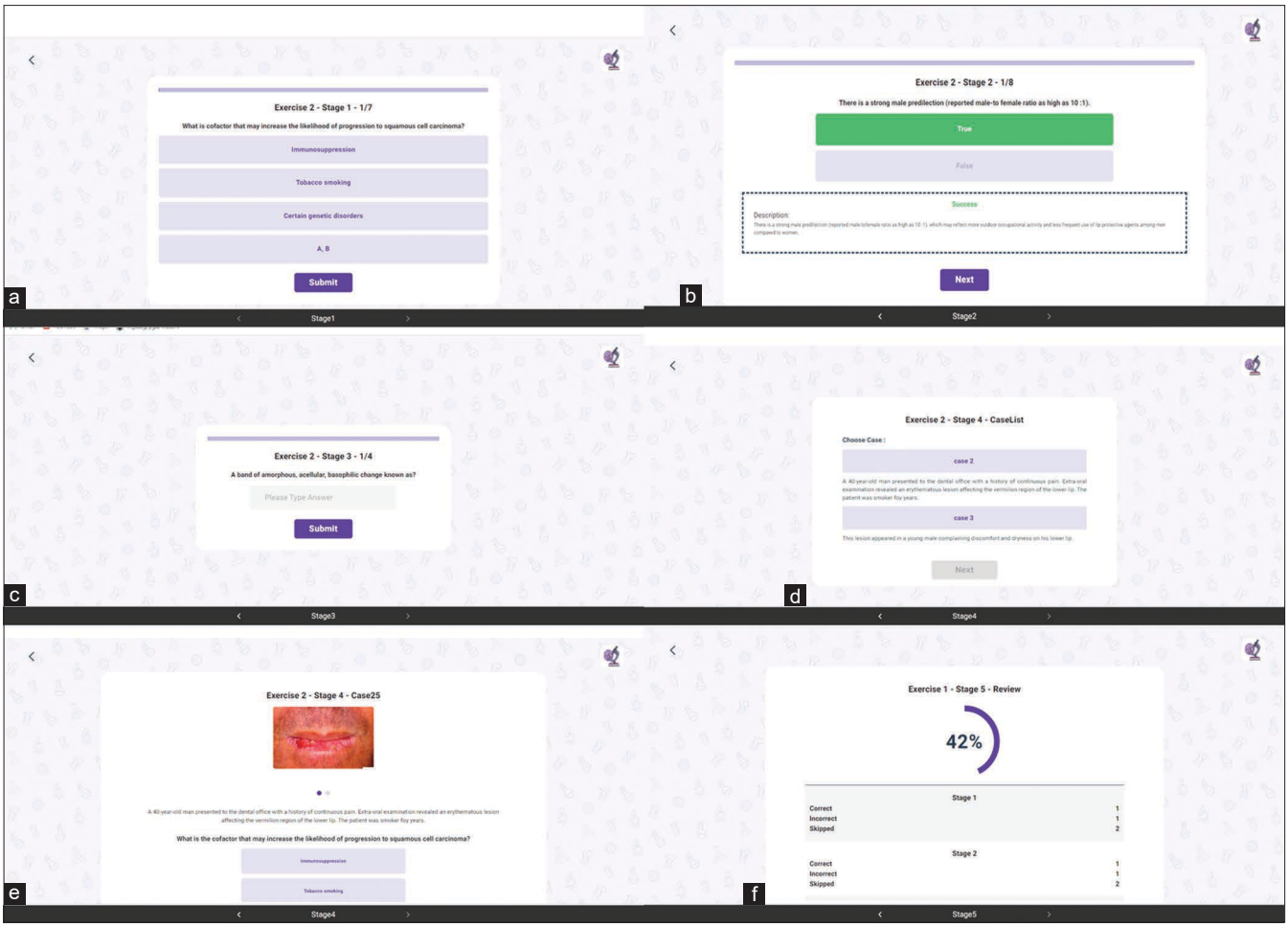

Figure 3: Stages of application. (a) Four-choice question in stage 1, (b) True–False question in stage 2, (c) Short answer question in stage 3, (d and e) Case questions, (f) Review in stage 5.

wrong questions of each exercise will be repeated in the next exercise [Figure 2].

At the end of each lesson, scoring is performed according to the user's performance as the percentage of correct answers out of all the questions in the completed exercises. Finally, this percentage is used to compare the strengths and weaknesses of the users.

Moreover, a list of the top scores obtained by users is maintained and updated and can be displayed on a separate page for motivating students to never give up learning.

Software section

To implement the proposed application that was introduced in the previous section, the general process of software engineering has been used. According to this process, the application design starts from the "communication" phase. At this stage, the requirements and details related to the features of the application are specified. Then, in the "planning" phase, the requirements are prioritized for implementation. In the third stage of "modeling," the software development team analyzes and designs different parts of the application according to the identified requirements and defines its structure. Then, in the fourth stage of "construction," the application is implemented according to the design phase artifacts. Simultaneously, with the implementation of the application, its various parts have been tested, and appropriate action has been taken to fix the discovered errors. The result of this activity is an error-free application that is ready to use and available to different users in the "deployment" stage. It should be noted that new requirements may have been identified during development, so the stages of communication, planning, modeling, and construction may have been repeated several times during the project.

Pathology section

The content of the application questions was based on chapters 10 and 11 of Neville's Pathology Book

2016, which was compiled by a dental student under the supervision of two professors specializing in oral and maxillofacial pathology.

Evaluation process

To access the data, including average scores and examination answer sheets, consent was obtained from all of the participants. The application was accessible to students before the midterm and final examinations and was introduced to them as an educational tool, and they were encouraged to use it. After the midterm and final examinations, the relationship between using or not using the application and the mean score of the questions about shared topics in the lesson plan and the application was investigated. In addition, the mean score of questions about topics shared between the lesson plan and the application was compared with the mean score of questions not included in the application's content.

Finally, a satisfaction questionnaire [Table 3] containing demographic characteristics and 19 questions on a Likert scale was provided to all participating students after the examination. The internal consistency of the questionnaire (reliability) was obtained through Cronbach's alpha, which was 88.8% for the midterm examination and 93.8% for the final examination. For the validity of the questionnaire, it was provided to 10 faculty members of the Isfahan Faculty of Dentistry, and their opinions were applied to the questionnaire content.

To ensure the accuracy of the results, a double-blind statistical analysis was performed (by an individual other than the study researchers). Data analysis was performed using SPSS software version 20. Paired *t*-tests were used to compare the mean scores of questions related and unrelated to the application. Moreover, to investigate the relationships between demographic characteristics and the scores obtained, independent *t*-tests and Pearson and analysis of variance (ANOVA) tests were used. The significance level of the tests was considered to be 0.05.

RESULTS

The mean age of the students was 21.8 ± 5.1 years, and their mean average score was 16.4 ± 2.1. Sixty-four students (57.1%) were male, and 48 (42.9%) were female. In total, 45 students (40.2%) had used the application.

Midterm examination

In the midterm examination, the mean score of satisfaction with the application was 76.8 ± 8.6. In addition, the mean scores for questions related and unrelated to the application were 71.5 ± 15.5 and 70.4 ± 14.9, respectively.

On the midterm examination, there was no significant difference between the mean scores of questions related or unrelated to the application for the students who used the application (P = 0.90) and those who did not, according to the *t*-test (P = 0.31).

The ANOVA test showed that in the midterm examination, there was no significant difference between the mean scores of questions related (P = 0.50) and unrelated to the application (P = 0.23) in students who used the application and those who did not. It should be noted that the mean scores of application users were higher for both groups of questions—those related to and unrelated to the application—but this difference was not statistically significant.

An inverse relationship existed between the age of the students and the mean scores of questions related (P = 0.02) and unrelated to the application (P = 0.01) according to the Pearson correlation coefficient. In addition, students' average score had no significant relationship with the score of satisfaction with the application (P = 0.79), while it had a direct relationship with the mean scores of

Table 1: Comparison of the mean scores of questions related and unrelated to the application, considering use and not using the application

Using the application	Questions related to the application, mean±SD	Questions unrelated to the application, mean±SD	*t*		
			t	df	*P*
Yes	61.2±15.7	69.7±14.7	−3.09	44	0.003
No	53.1±15.8	64.5±16.1	−6.65	66	0.001

SD: Standard deviation

Table 2: Comparison of the mean scores of questions related and unrelated to the application between students who had used the application and those who had not

Score	Using application, mean±SD	Not using application, mean±SD	ANOVA		
			df	*F*	*P*
Related questions	61.2±15.7	53.1±15.8	1	7.22	0.008
Unrelated questions	69.7±14.7	64.5±16.1	1	2.98	0.04

SD: Standard deviation

questions related ($P < 0.001$) and unrelated to the application ($P < 0.001$).

The mean score for questions unrelated to the application was significantly greater for women than for men ($P = 0.007$).

In the midterm, the mean score of satisfaction with the application was 76.8 ± 8.5. In addition, the mean scores of questions related and unrelated to the application were 71.5 ± 15.5 and 70.4 ± 14.9 out of 100, respectively.

Final examination

The paired *t* test showed that in the final examination, for the two groups of students who had used the application ($P = 0.003$) and those who had not ($P < 0.001$), the mean score of questions unrelated to the application was significantly greater than that of the questions related to it [Table 1].

The test showed that on the final examination, the mean scores for questions related to the application ($P = 0.008$) and unrelated to the application ($P = 0.04$) were significantly greater for students who used the application than for those who did not. The mean scores for questions related and unrelated to the application were greater for students who used the application [Table 2].

The Pearson correlation coefficient showed an inverse relationship between students' age and the mean scores of questions related ($P = 0.009$) and unrelated to the application ($P = 0.003$). Moreover, the average score of students had a direct relationship with the scores of questions related ($P < 0.001$) and unrelated to the application ($P < 0.001$). In other words, students with a high average score had a higher mean score for questions related and unrelated to the application.

The independent *t*-test showed that in the final examination, the mean score of satisfaction for female students who were unrelated to the application ($P = 0.03$) was significantly greater.

Table 3: Valid percentage of each question in the satisfaction questionnaire after the mid-term and final examinations

Questions	Mid-term examination				Final examination			
	Low	Intermediate	High	Very high	Low	Intermediate	High	Very high
1. Was it easy for you to install and enter the application?	1.3	11.7	35.1	51.9	1.2	18.1	44.6	36.1
2. Was the application successful in saving your data?	1.3	14.3	41.6	42.9	2.4	20.5	43.4	33.7
3. In your opinion, did the content of four-choice questions match the content of lesson plan?	2.6	15.6	49.4	32.5	3.6	21.7	49.4	25.3
4. In your opinion, did the content of true–false questions match the content of lesson plan?	0	16.9	53.2	29.9	3.6	28.9	49.4	18.1
5. In your opinion, did the content of short-answer questions match the content of lesson plan?	2.6	18.2	53.2	26.0	6.0	22.9	55.4	15.7
6. In your opinion, did the content of cases match the content of lesson plan?	1.3	26.0	50.6	22.1	1.2	32.5	49.4	16.9
7. Is the quality of images uploaded in the application suitable for you?	1.3	9.1	42.9	46.8	3.6	18.1	47.0	31.3
8. Did you like the application design?	5.2	28.6	42.9	23.4	2.4	28.9	43.4	25.3
9. Has using this application been effective in reducing your stress during the examination session?	18.2	44.2	24.7	13.0	10.8	37.3	37.3	14.5
10. Has using this application been effective in improving knowledge and understanding of oral pathology?	2.6	24.7	51.9	20.8	1.2	33.7	43.4	21.7
11. Has using this application been effective in increasing your interest on studying pathology?	5.2	39.0	41.6	14.3	8.4	28.9	45.8	16.9
12. Do you find this learning method fun and challenging?	3.9	31.2	49.4	15.6	7.2	31.3	45.8	15.7
13. Do you find this method effective in learning the content of lesson plan?	0	27.3	45.6	27.3	1.2	28.9	48.2	21.7
14. Do you find this method effective in reviewing the content of the lesson plan before the examination?	7.8	28.6	39.0	24.7	7.2	32.5	39.8	20.5
15. Has the application increased your confidence in the examination session?	2.6	41.6	39.0	16.9	12.0	32.5	39.8	15.7
16. Do you find this application effective in increasing your self-confidence in the clinical diagnosis of patients?	9.1	36.4	46.8	7.8	9.6	27.7	48.2	14.5
17. Has this application been effective in memorizing the histopathological and clinical characteristics of the lesions?	2.6	24.7	53.2	19.5	3.6	27.7	49.4	19.3
18. Has the experience of using this application been satisfactory for you?	1.3	20.8	46.8	31.2	3.6	28.9	49.4	18.1
19. Would you recommend this app to others?	2.6	15.6	51.9	29.9	1.2	21.7	53.0	24.1

The frequency distribution of each question in the satisfaction questionnaire in the midterm and final examinations showed that the highest percentage of satisfaction was among the users, including easy installation and entry into the application, acceptable quality of uploaded images, successful storage of application information, relevant content of the 4-choice questions, and satisfactory experience with the content of the lesson plan and the application usage. The highest frequency of low satisfaction responses among users included reduced stress during the examination session due to using the application and improving students' self-confidence in clinically diagnosing patients [Table 3].

DISCUSSION

In the present study, the average age of the participants was 21.8 years, and most of them were men, with a mean average age of 16.4 years. After designing a learning application and its voluntary implementation for the students of the 6th semester in 2022–2023, the results of the students' midterm examination showed that the mean score of the questions related to the application was higher for both groups of students who had used the application and those who had not. This may be related to the simplicity of the content for the midterm; however, the difference was not significant. In fact, regarding the question's difficulty, both groups could easily identify the correct option.

The application satisfaction scores among the students who used this method were 76.8% and 74.8% in the midterm and final examinations, respectively, which was due to the innovative design of the application, the novelty of this method in education, its entertaining and challenging nature, its effectiveness in learning the lesson content, and its helpfulness in the retention of lesion tips to remember. This indicates that the application was user-friendly and that all users were relatively satisfied. In line with the present study, Arayapisit *et al*. investigated the use of educational games in learning about orofacial infections in Thailand in 2022, and the findings showed a significant increase in students' evaluation scores. The students were satisfied with this method and found it to be entertaining and effective in learning, understanding concepts, clinical application of knowledge, and content review.[25]

The mean score of questions related and unrelated to the application had an inverse relationship with students' age. In other words, with increasing age, the mean scores of questions related and unrelated to the application decreased because older students were more occupied with their occupations or family responsibilities and consequently lacked adequate time to study or were less motivated. Notably, young people are more likely to utilize technology than older people are. Moreover, the mean score of questions related and unrelated to the application was directly related to students' average score, indicating that pathology knowledge was more important for students who had obtained higher grades in other subjects or that the importance of the grade obtained in this subject and its effect on the average score was greater for them. Accordingly, they devoted more time to studying it or were more motivated. Regarding gender, there was no significant difference in the satisfaction score with the application between male and female students, indicating that both groups of students appreciated the application, and its feedback had no relationship with their gender.

In total, 40.2% of the students used the application. Despite encouraging the students to use the application, the acceptance level of this method by the students was not as expected, which can be attributed to the low internet speed in the country, the lack of motivation to study, especially in basic courses such as oral and maxillofacial pathology, the difficulty of pathology topics, and the large amount of information materials presented. Other reasons include the short examination preparation time, the intensive midterm and final examinations, the prevailing culture of giving importance to specialized courses other than pathology, and the lack of awareness of the importance and clinical application of this knowledge in the patient examination, diagnosis, and management of pathological lesions. Approximately 57.7% of the students who used the application were female, which was probably due to female students' greater interest in using electronic devices, greater use of educational aids by females, greater time devoted to study, and greater effort in acquiring higher scores.

The results of the final examination showed that the mean scores for questions related and unrelated to the application were significantly greater for students who had used the application, indicating that using the application familiarized students with questions and helped them answer more questions unrelated to the application in addition to more related questions [Tables 1 and 2]. The difference in the results of the

midterm examination could be due to the students' less familiarity with the use of the application; over time, the students became completely familiar with the application and obtained better results.

In the final examination, age had an inverse relationship with the mean scores of related and unrelated questions, while the average score had a direct relationship with the scores for reasons similar to those of the midterm examination. Concerning the students' gender, the mean satisfaction and related scores were greater for women than men; however, there was no significant difference. The importance of this subject's scores and their effect on the overall average score were probably greater for female students; as a result, the motivation, effort, and study time allocated were greater.

In line with the present study, to facilitate the learning of neurology in residents, Raskurazhev *et al*. designed and developed a game-based learning application in Russia in 2021 and evaluated the effectiveness of that method through an approach that varied from that used in the present study. By comparing the results of a questionnaire with the content of neurology questions before and after using the application, the mean scores of the questionnaire after using the application were significantly greater. Moreover, similar to the present study, the results were not correlated with students' gender.[23]

This study showed that the mean scores for questions related and unrelated to the application were greater for application users. Eighty percent of those who had used the application for the midterm examination used it in the final examination, and 9% of new users used it in the final examination evaluation. This increase could be as a reason for previous familiarity, accessibility of the application in a more extended time and its effect on the student's grades, allocating more examination preparation time for the final examination rather than the midterm examination, and the importance of final examination grades compared to the midterm examination from the students' point of view.

In this regard, the findings of Tsopra *et al*.'s (2020) study on the use of a game in pharmacology education in France showed a significant positive correlation between students' scores on the application and their final examination grades. The students who had used the application obtained a higher grade on their final examination. In addition, the students believed that using the application was an entertaining method for reviewing the educational content and was effective in their understanding.[18]

Contrary to the present study, Courtier *et al*. designed and developed a game for the radiology course in 2016. In contrast, they put the students in two groups: traditional education and education through games. In the final examination, the results showed that the traditional education group obtained higher grades than did the education through the games group. According to the satisfaction questionnaire, education through games was entertaining for students, similar to the findings of the present study; however, in contrast, it did not greatly increase students' interest.[24] The difference between the results of the above study and the present study was due to the use of dissimilar evaluation methods. In the present study, the combined teaching method, adding a game to traditional teaching methods, was used; however, in the above study, education was provided through games and traditional methods separately in the two groups. Therefore, the combined teaching method had a more significant effect on students' learning and understanding of the material.

In general, the evaluation of the satisfaction questionnaire separately in both the midterm and final examinations showed that the installation and login to the application, as well as the successful storage of information, were highly satisfactory for most users, indicating the application's faultless design in these areas.

Furthermore, in both examinations, the content of the application questions (including four-choice, true–false, and short-answer questions and cases), which were designed under the supervision of oral pathology professors, was proportionate to the lesson plan content. The quality of the uploaded application images was acceptable according to most users. Moreover, the design of the application was appreciated by the majority of users. The impact of the application in acquiring pathology knowledge on both examinations was high for most students. Interestingly, the impact of the application in increasing students' interest in this knowledge and learning lesson plan content was moderate to high for most individuals on both examinations. In line with the present study, a study conducted by Felszeghy *et al*. in 2019; in Finland, on using a game-based platform to improve students' performance and encourage them to participate in histology education showed that this method was successful and that its

users were highly satisfied. This method increased students' motivation to learn, and the gamification approach increased students' interest.[26]

In this study, most users in both examinations found this method entertaining and challenging. Gudadappanavar *et al*., who investigated the effectiveness of game application on the learning of pharmacology in students in 2021, reported that students' feedback and interest in the application group were greater in the present study, and they considered this method amusing and dynamic.[15] Similar to the study by Tsopra *et al*., who reported this method to be effective in reviewing educational content and understanding students, the effectiveness of the application in reviewing lesions before the examination in this study was moderate to high.[18] In line with this study, Raskurazhev *et al*. reported that most students found the application satisfactory and recommended it to others.[23] Despite the students' high satisfaction with the design of the application and its content questions, its entertaining nature, and its better impact on learning the course content, this method seems to be less effective in reducing the students' stress in the examination session and increasing their self-confidence when facing actual clinical cases [Table 3]. The reasons for this could be the challenging nature of pathology, the large quantity of examination content, the short examination preparation period, inadequate study during the semester, the theoretical nature of the content, and perhaps, the difficulty of the questions designed for the examination.

CONCLUSION

The results showed that new educational methods, such as applications, improved students' knowledge and understanding of pathology. Fortunately, the users' satisfaction and interest confirmed the success of the present application. Therefore, this method can be used to increase students' learning of extensive medical science.

Ethics approval and consent to participate

A recent study was approved by the research committees of the vice-chancellor in research affairs, University of Isfahan, with the number IR.MUI. RESEARCH.REC.1401.171.

The consent form was obtained from all participants, and we informed them about all parts of the study clearly.

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or non-financial in this article.

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