Original Article

Journal of Advances in Medical Education & Professionalism

Effectiveness of Gamification in Enhancing Learning and Attitudes: A Study of Statistics Education for Health School Students

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Abstract

Introduction: Gamification is the use of game design elements in non-game contexts. It is considered a student-centered instructional design to motivate student learning and academic behavior. In this study, the effects of gamification on learning statistics (hypothesis testing issue) and attitude toward statistics in comparison with the common e-learning approach were investigated. The students' experience and critical elements of gamification on learning statistics were assessed, too.

Methods: In a before and after trial, in a census manner, 64 health faculty students of Guilan University of Medical Sciences, Rasht, Iran, non-randomly were assigned to the intervention (n=42) and control (n=22) groups. Learning activities were gamified in the intervention group, while the control group received traditional problem-solving in the learning management system. Narrative, avatar, level, point, progress bar, scoreboard, challenge and feedback elements were used in the game experience. The implementation of gamification was applied based on Landers' theory of gamified content. Valid and reliable Persian version of the Survey Attitude toward Statistics questionnaire measured the students' attitude before and after the intervention. The EGameFlow questionnaire and a valid and reliable researcher-made exam measured the users' experience of gamified content and learning hypothesis testing after the intervention. The independent samples T-test, analysis of covariance and the partial eta-squared effect size were calculated by SPSS software, version 26.

Results: Compared to the control group, the intervention group had a more positive attitude toward learning difficulty (moderate partial eta-squared 0.099), value and cognitive competency (weak partial eta-squared=0.01 and 0.05). Learning between the two groups was not different (P=0.522). There was a significant correlation between learning and the students' perceived experience with feedback (r=0.583, P<0.001), concentration (r=0.509, P=0.005), and challenge (r=0.421, P=0.023) of the gamified content.

Conclusion: It suggests using gamification on learning statistics while optimizing the design with more focus on the feedback, challenge and concentration elements.

Keywords: Gamification; Learning; Attitude; Biostatistics; Students

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Please cite this paper as:
Khoshnoodıfar M, Ashourı A, Taherı M. Effectiveness of Gamification in Enhancing Learning and Attitudes: A Study of Statistics Education for Health School Students. J Adv Med Educ Prof. 2023;11(4):230-239. DOI: 10.30476/JAMP.2023.98953.1817.

Received: 22 May 2023
Accepted: 6 August 2023

Introduction

The development of statistical thinking is of great importance at all educational levels, and learning statistics is considered a core subject in almost all fields of medical sciences (1, 2). In general, learning statistics provides potential skills for performing logical reasoning, critical thinking, development of interpretation and evaluation skills, and ease of dealing with entirely abstract concepts for learners (3). Also, this course plays an essential role in the career path of the students of medical sciences to understand and conduct scientific research (2).

However, learning statistics is challenging for many learners (4, 5). It is because of complexity and non-intuition of statistical concepts, lack of necessary mathematical knowledge or difficulty in dealing with the context of the problems and emotional issues, such as statistical anxiety, lack of self-efficacy and negative attitude towards statistics (3, 6-8). Some studies have reported that learners misunderstand most statistical concepts, such as descriptive statistics, probability, and statistical inferences (8), indicating insufficient learning in traditional teaching approaches.

Studies in statistics education show that using active learning methods, humor, and computer and information technology allows learners to discover, construct and understand important statistical concepts, and engage in statistical thinking. Also, these approaches can increase self-confidence, facilitate understanding of statistical concepts, increase knowledge retention, and improve learners' performance (9, 10). The Guidelines for Assessment and Instruction in Statistics Education (GAISE) College Report published in 2016 also emphasizes the attention to active learning in statistics education (11).

Active learning means a set of approaches that engage learners in doing work or thinking about what they are doing (12). In other words, active learning is anything related to learning other than just looking, listening, and taking notes that all learners in the class are asked to do (13). Nowadays, especially after the COVID-19 pandemic, the development of using electronic platforms in education has provided a favorable condition for using new approaches in education. One of them is gamification, a strategy that has been considered to improve active learning (14). Gamification is the use of game design elements in non-game contexts (15). It seems that gamification through increasing motivation, engaging activity, and maintaining interaction with the content can be useful and positively affect learning (15-17). Also, the compatibility of games with active learning methods and effective learning has caused interest in using games and gamification in teaching and learning (18, 19).

Two meta-analysis studies, including research in different fields, show that applying gamification in education can improve cognitive, motivational and behavioral learning outcomes with small to medium effect sizes (0.25 to 0.56). However, according to the available investigations, the size of the reported effect on the motivational and behavioral outcomes is not stable (19, 20). Although studies in gamification of adult education are increasing, there are still many unanswered questions in this field. For example, the effectiveness of gamification in different contexts and subjects has remained unclear (20-22), the key elements of gamification or the combinations that have the greatest impact are not known (23-25), and there is not enough knowledge about factors contributing to successful gamification (19, 21). Also, which features of games are more effective in supporting which type of learning or how different games influence learning is unknown (19, 24).

There are limited studies with contrary results about the effects of gamification on statistics learning (10, 26-28). So, this study was designed to investigate the impact of using gamification on the health faculty students' learning and attitude toward statistics compared with the common electronic learning approach. Additionally, the study aims to examine how students experience gamification and which elements of gamification are related to their learning of statistics. Since hypothesis testing in inferential statistics is one of the critical concepts and various studies have addressed misconceptions and learners' difficulty understanding this topic (8, 10), in this study, the issue of hypothesis testing was selected. So, learning activities were gamified as active problem-solving.

Methods

Participants

In a quasi-experimental study, in a census manner, all undergraduate students studying in the health major taking the biostatistics course at the health faculty of Guilan University of Medical Sciences (GUMS) between October to January 2021 were enrolled in this study. Inclusion criteria was taking the biostatistics course in Autumn semester 2021 in health faculty of GUMS. Students with a history of taking statistics courses or unwilling to participate in the study were excluded. Also, students who stated they did not study the educational content or didn't attend the learning evaluation were withdrawn from the study.

According to the results of the Delgado-Gomez et al.'s (2020) study, the standard deviation of the learning score were 3.05±1.58 in the intervention group (receiving learning with gamification) and 1.21±1.00 in the control group (receiving learning without gamification) (10). Regarding α=0.05 and power of 0.80, the minimum sample size required in each group was calculated as at least 16 students. Three classes of students who enrolled in the study were assigned to the intervention (2 classes, n=42) or control group (1 class, n=22) in a nonrandom manner (Figure 1). At the enrollment, students were unaware of their allocation group. It was emphasized that learners do not exchange their educational content with other students' classes until the end of the study.

Educational content and learning activities

The e-learning content of statistical hypothesis testing was provided for studying in 2 weeks. The general goals were introducing inferential statistics and statistical hypothesis testing of a mean or proportion. Objectives were defined as follows: 1) understanding the concept of inferential statistics and the difference between census and sampling, 2) writing null and alternative hypotheses, 3) understanding type I and II error and significance level, 4) calculating hypothesis testing statistics, 5) determining the critical region and 6) making the decision to reject or fail to reject about the null hypothesis.

In the educational content, as prerequisites, the mean, standard deviation (SD) and proportion calculating, familiarity with standard normal distribution, t-student distribution, central limit theorem and sampling distribution were reviewed, and essential notes were mentioned. The educational content included the lecture, questions and answers, and examples of problem-solving.

The content of learning activities by instructional objectives included [1] recalling concepts related to inferential statistics and hypothesis testing (15 true-false questions), [2] recalling test criterion values from the standard normal probability distribution (3 multiple-choice questions), [3] conducting a hypothesis test for a mean and proportion (3 problem-solving segmented in sixteen 4-choice questions and [4] one problem-solving question including five short-answer or fill in the blank questions). In addition, 20 optional questions in the form of 4-choices were given. Some questions required calculations and responding to the learning activities content was estimated to be about one hour.

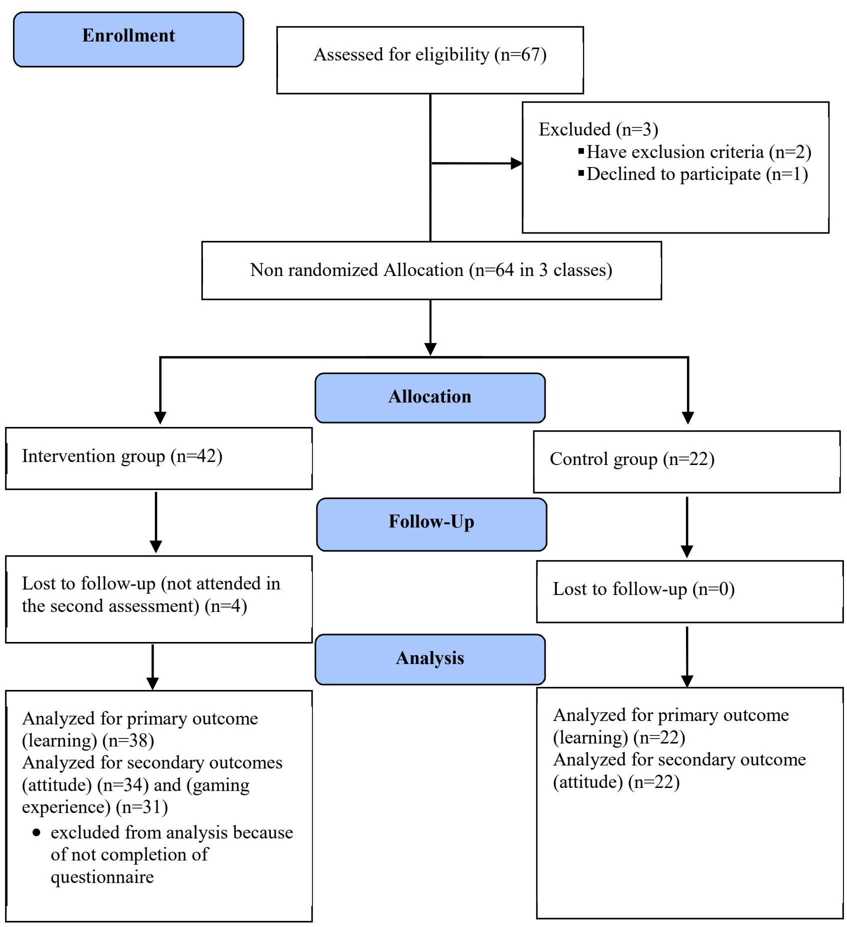

Figure 1: Flow Diagram of study participants

Gamification of learning activities

The intervention group received learning activities that were gamified. The game experience was created through the use of various game elements or mechanics, including narrative, avatar, level, points, progress bars, scoreboards, challenges, and feedback.

During the design step, key information such as the overall concept of the game, narrative, characters, environment, how to play the game, rules, scoring and feedback system, as well as the visual, sensory and artistic aspects was taken into consideration. Technical and software requirements of the game were also determined (29). The game features were documented based on the gamified learning theory of Lander (30). A detailed summary of these characteristics is presented in Table 1.

The control group, on the other hand, received learning activities that had the same content as the intervention group but were designed using conventional electronic learning methods, such as multiple-choice or short-answer questions that provided instant feedback. To create motivation for studying and encourage critical thinking in the control group, no explanations or details of problem-solving were provided instantly with the learning activities. The intention was to prompt students to think about the problems and find solutions independently. The control group was given the document containing details of the solutions, four days before the learning assessment.

All contents were prepared by Articulate Storyline 360 software (31, 32) and located in the learning management system (LMS). The face and functional validity of the gamified content were assessed by an expert panel and two students in a pilot study, and the necessary corrections were made before the intervention.

Instruments

Demographic characteristics, including gender, age, semester, total grade point average,

Table 1: Gamification component by Bedwell game attributes category and based on Landers theory of gamified learning

Game attributes	Gamification elements
Action Language	The student played the game as a single user on the computer or smart phone online, using the computer keyboard or mouse or touching the phone screen and typing.
Assessment	For all activities, instant feedback of correctness or incorrectness, explanation of wrong options, earning or deducting points, points of each level, total points, scoreboard and flag of the successful passage of the level or challenge were provided. Moving from each level to the next level depended on taking the minimum target score set at each level.
Conflict/ Challenge	According to the learning objectives, the content was designed in 5 levels with increasing difficulty. The student answers questions with different Bloom's taxonomy, including knowledge, understanding, application, and analysis. In the levels of the first to third, the feedback includes whether the answer is correct or incorrect, an explanation of the correct answer and the reasons for rejecting the other options (this feedback is displayed if the wrong option is selected). In the fourth level and final challenge, the feedback only includes whether the answer is correct or incorrect. In the last challenge, the wrong answer was accompanied by a deduction of points.
Control	The player chooses an avatar as the narrator. At the end of each level, the player can replay that level and gets a higher score or go to the next level. Also, if the player receives the desired score, the player will skip the final challenge at own discretion.
Environment	The game environment was designed two-dimensionally with the experience of the health major student's life reality to remember what was learned and help others solve the problem.
Game fiction	In the game, the student is looking for help to solve the question of two young health employees. For this purpose, the player goes through the stages of recalling the knowledge and concepts of hypothesis testing and conducting some examples of hypothesis testing. In the fourth level, the player solves the relevant employees' question. Lastly, the student deals with the challenge of skill and mastery in conducting hypothesis testing. The game occurs in various collegian backgrounds, including a coffee shop, library, tablet or pen and paper on a table.
Human interaction	The interaction of students with each other and the instructor was planned through the class WhatsApp group outside the game so that students could share their progress, ask questions and receive relevant guidance.
Immersion	Computer or smart phone interfaces were considered for playing to facilitate the immersion. Touch, drag and drop and typing were used to play the game. Feedback in the form of the avatar face or a failure or success voice was provided. At the first level, pseudo competition between the player and avatar, using a designed algorithm, was an attempt to involve the player emotionally and believability of the game characters. In various cases, clues (such as images for the formulas guide) were used to keep the player engaged with the game and overcome the challenges. To create a sense of security and avoid failure, each stage of the game could play again.
Rules/Goals	The game's general purpose and how to play it were explained upon entering the game. In an overview, the path of the game and the topic of each level were displayed for the player. The player should answer all the questions at each level. To pass each level and unlock the next level, the player should earn a specific score informed at the beginning of each level.

history of playing digital games, and frequency of games played per month, were recorded. Students' attitudes were measured by the Survey of Attitudes Toward Statistics (SATS-36) (© Schau et al., 2003) questionnaire (7, 33). The scale consists of 36 Likert items from strongly disagree [1] to strongly agree [7]. It assesses six components, including Affect (six items about positive and negative feelings about statistics), Cognitive Competence (six items evaluate attitudes about intellectual knowledge and skills when applying statistics), Value (nine items about the attitude towards the usefulness, relevance and worth of the statistics in personal and professional life), Difficulty (seven items about the attitude towards the difficulty of statistics as a subject), Interest (four items about the level of interest aspect of the intrinsic value) and Effort (four items about the amount of work that the learner spends on learning statistics). A higher value on each component shows a more positive attitude. The validity and reliability of the Persian version of the scale have been confirmed using confirmatory factor analysis. Cronbach's alpha coefficient for affect, cognitive competency, value and difficulty was 0.79, 0.76, 0.82 and 0.57 (34). Cronbach's alpha coefficient for interest and effort was calculated in a pilot study as 0.89 and 0.80, confirming the reliability.

Learning the subject of hypothesis testing was measured through an exam constructed by the instructor. It consisted of 15 multiple-choice questions related to each instructional objective. The validity of the content was confirmed by a panel of experts, including two statistics specialists and one instructional evaluation specialist. The reliability of the examination was approved by the Kuder-Richardson coefficient (0.83 in a pilot study). Also, the intervention group students were asked to report the frequency of studying with gamified content.

The EGameFlow questionnaire assessed students' experience with gamified content (35). The questionnaire includes 42 items in 8 subscales (Concentration including six items, Goal Clarity 4 items, Feedback 5 items, Challenge 6 items, Autonomy 3 items, Immersion 7 items, Social Interaction 6 items and Knowledge Improvement 5 items). Each item is measured with a likert scale of 7 points from strongly disagree [1] to strongly agree [7]. The questionnaire determines the user's enjoyable experience with the game, and the higher scores calculated from the sum of points indicate a better user experience. Cronbach's alpha coefficient for the Persian version of the questionnaire calculated in a pilot study was 0.95 overall and 0.70 for concentration, 0.92 for goal clarity, 0.92 for Feedback, 0.82 for challenges, 0.85 for autonomy, 0.88 for Immersion, 0.91 for social interactions and 0.56 for Knowledge Improvement subscale which indicates the acceptable reliability of the scale. All questionnaires and learning tests had been prepared electronically and completed online.

Procedure

At the beginning of the course, in an online class, the researcher explained the aim and process of the study to students. They were informed that participation was voluntary and their information would remain anonymous. After five asynchronous class sessions, in an online session, the researcher practiced and reviewed the prerequisites of hypothesis testing issues (as mentioned above) and answered students' questions. After that, the students giving informed consent completed a questionnaire including demographic characteristics and the pre-intervention version of SATS-36. Then, students of both groups, in parallel, received the same educational content of the hypothesis testing. The content was provided to them in the LMS to study in two weeks. The control group solved practice problems as learning activities and uploaded them in the LMS, but the intervention group used the gamified content of the practice problems. After the study deadline, in an online session, students of the two groups completed the post-intervention version of SATS-36. Also, the intervention group completed the Egameflow questionnaire. Then, all students participated in the learning evaluation. The study was approved by the ethical committee of Shahid Beheshti University of Medical Sciences (approval ID: IR.SBMU.SME.REC.1400.062). Informed written consent was obtained from all participants.

Statistical analysis

Frequency (percentage) and mean (standard deviation) or median (range) were used to describe the data. The Kolmogorov-Smirnov test was performed to assess the normal distribution of quantitative variables, which was valid for all characteristics (except the frequency of games played per month). Independent samples t-test, Mann-Whitney U test or chi-square test were used to compare the characteristics between the intervention and control groups. Analysis of covariance (ANCOVA) was used to assess the effects of the intervention, adjusting to the baseline values recorded before the intervention. Homogeneity of variance and parallel regression line assumptions were examined and met in all analyses. The effect size of partial eta squared was reported and values of 0.01–0.06, 0.06–0.14, and more than 0.14 were considered small, medium, and large effects, respectively. Partial eta squared lower than 0.01 indicated a negligible effect. The significance level of the tests was considered 0.05. IBM SPSS software, version 26.0 (IBM Corp., Armonk, NY) was used for data analyses.

Results

Students' characteristics

The demographic characteristics of the students are shown in Table 2. In total, 64 undergraduate students in health majors (control group, n=22 and intervention group, n=42) with a mean age of 20.5 years (SD: 1.1, range: 19 to 23) were included in the study. Fifty-two (81%) of the participants were female. More than half of the students said they had never played digital games or rarely played (64%). There was no statistical difference between the two intervention and control groups regarding demographic characteristics.

Students' attitude toward the statistics

Students' attitude toward the statistics is described in Table 3. At the beginning of the study, attitude in all components in both groups was moderately positive, and only attitude toward difficulty was low, so students thought statistics was a difficult subject. Although the control group had a more positive attitude in all components, no component of attitude differed significantly between the groups (P>0.05 for all). After the intervention, attitude toward difficulty was significantly more positive in the intervention group than in the control group (3.75±0.79 vs. 3.16±0.92, P=0.019, Table 3). Gamification improves the attitude about the difficulty of statistics learning with a moderate effect size. Also, according to the effect sizes, gamification affected the value and cognitive competency of

Table 2: Demographic characteristics of the students participating in the study

Characteristic	Total (n=64)	Intervention group (n=42)	Control group (n=22)	P
Gender				
Female	52 (81)	32 (76)	20 (91)	0.193
Male	12 (19)	10 (24)	2 (9)	
Age in year, (mean±SD, range)	20.47±1.10 (19-23)	20.54±1.27 (19-23)	20.35±0.76 (19-22)	0.782
Semester				
Three	47 (73)	27 (62)	20 (91)	0.001
Four	17 (27)	15 (36)	2 (9)	
Total GPA, (mean±SD, range)	16.16±1.23 (13-18.59)	16.17±1.33 (13-18.59)	16.13±0.98 (14-17)	
History of playing digital games**				0.401
Never	5 (9)	2 (6)	3 (15)	
Few	30 (55)	19 (54)	11 (55)	
Average	13 (24)	10 (29)	3 (15)	
A lot	7 (13)	4 (11)	3 (15)	
Games played frequency per month (median, range)	4 (1-60)	4.5 (1-60)	3.5 (1-50)	0.993

The values are frequency (percent), otherwise described. GPA indicates grade point average and SD, standard deviation. *P-value was reported to compare groups for baseline characteristics. **The difference from the total number was due to missing data.

Table 3: Attitudes toward statistics component measured at baseline and after the intervention

Dimensions	Intervention group (n=42)			Control group (n=22)			P**	Partial eta square
	Baseline	After intervention	Adj. mean (95% CI)*	Baseline	After intervention	Adj. mean (95% CI)*		
Affect	4.29±1.44	4.08±1.39	4.12 (3.72-4.51)	4.63±1.16	4.17±1.34	4.12 (3.63-4.61)	0.990	<0.001
Value	4.67±1.12	4.63±1.22	4.71 (4.43-4.98)	5.11±0.96	4.44±0.89	4.33 (3.98-4.68)	0.099	0.051
Cognitive competency	4.47±1.29	4.48±1.15	4.54 (4.23-4.84)	4.91±0.88	4.44±1.04	4.35 (3.97-4.72)	0.431	0.012
Difficulty	3.64±0.87	3.75±0.79	3.72 (3.46-3.97)	3.48±0.82	3.16±0.92	3.22 (2.90-3.54)	0.019	0.099
Effort	5.78±0.99	5.57±1.20	5.64 (5.32-5.96)	6.18±0.68	5.69±0.94	5.58 (5.18-5.98)	0.808	0.001
Interest	4.47±1.63	4.50±1.68	4.50 (4.10-4.91)	4.73±1.22	4.32±1.35	4.32 (3.81-4.82)	0.568	0.006

The values are mean±SD, otherwise described. Possible range is 1 to 7. SD indicated standard deviation; Adj, adjusted; CI, confidence interval. *Post intervention mean, adjusted to the baseline measures and related 95% confidence interval was reported. **P-value was reported from the analysis of covariance to compare groups post intervention, controlling for the baseline values.

learning statistics with a weak effect size (partial eta square between 0.01 and 0.06). Other attitude components did not significantly differ between the groups (P>0.05 for all, Table 3).

Students' learning statistics

Regarding learning statistical hypothesis testing, comparing the mean scores showed no significant difference between the two groups (7.21±3.5 vs. 7.77±2.76 in the intervention and control group, respectively; P=0.522). Regarding the students' involvement with the game, the mean and standard deviation of the number of times entering the game according to the students' statements was 2.67±1.63 (range 1 to 6). The data showed a strong positive and significant correlation between game involvement and learning (P=0.002, r=0.565).

Students' experience with gamification

In the evaluation of the gamified content from the students' point of view, from the possible range of 1 to 7, the mean and standard deviation of the total score was 4.94±0.84. The aspects of knowledge improvement (5.29±1.04), feedback (5.23±1.08), challenge (5.16±1.03), and goal clarity (5.10±1.03) obtained a higher score than other aspects of concentration (4.92±1.13), control (4.81±1.18), social interaction (4.53±1.09), and immersion (4.52±1.23). The evaluation of the students in total and all dimensions was moderate to high (significantly higher than the average score of 4) (P>0.05 in all cases).

Discussion

In this study, the effect of using gamification on electronic learning and attitude toward statistics was investigated. Lesson learning activities were designed using the gamification approach with elements of point, level, challenge, scoreboard, feedback, narrative and avatar. The results indicated no significant difference between groups in learning; however, gamification improved students' attitudes regarding the difficulty of the statistics in a medium effect size and statistics value and cognitive competency in a weak effect size.

Similar to our study, research reported by Boyle, et al. (2014), Novak, et al. (2016), Smith (2017) and Wronowski, et al. (2020) indicates using gamification elements does not improve learning statistics (3, 27, 28, 36). However, the results of Delgado-Gomez, et al. (2020) and Legaki, et al.'s (2020) studies state students who experienced learning in a modified game environment had better learning (10, 26). The learning strategy of divide-and-conquer and the content exposure control in Delgado-Gomez et al.'s study may cause the different result. Also, considering that in the study of Legaki et al., most of the students were in the field of electrical and computer engineering and the greater familiarity of students with technology can be a reason for different outcomes. Furthermore, differences in designing the gamification can affect the results (23, 24). A study in the statistics course reported that social feedback's impact positively affects students' performance, while temporal-self feedback showed no effect (37). This issue strengthens the use of students' social comparison in the design of statistics course gamification, which was not used in the present study due to technical limitations. Also, another reason for the lack of observation of gamification's impact on learning may be that students employ all their efforts and facilities to get good grades in the evaluations in both groups. So, measuring the students' effort in acquiring this amount of learning and comparing it between the two groups can provide a better assessment.

Our gamified content improved students' attitude toward the statistics, which can be explained by elements used in the design. The narrative of the gamified content focused on the usefulness of the player's activity in serving and helping others positively impacted the students' attitude regarding the value of statistics and its benefits. However, since the enjoyment of the intrinsic value of the statistics was not been targeted, it did not have much impact on students' affect. It seems that the elements of point, feedback and scoreboard, through promoting self-efficacy and self-confidence, affected students' attitude toward their cognitive competency. It is similar to the Sailor, et al.'s study that badges, leaderboards, and performance graphs affect competence need satisfaction and task meaningfulness (24). Also, in our gamified content, in addition to the existence of learning activities prerequisite, the presence of guides and clues in the game, the presentation of problems in a step-by-step and segmented structure, and having control and authority lead to increased interaction and engagement. So, it effectively improved the attitude towards the difficulty of the nature of the statistics course. But on the other hand, the elements of our gamified content were not successful enough in making students interested in learning statistics and making more effort to learn. Similar to our results, other researchers also reported the effect of gamification on improving affective outcomes, including perceived cognitive competency, affective, value and difficulty of statistics (27) in using gamified modules in face-to-face class and/or improvement of engagement, absorption and interest in statistics by using a serious statistical game (28).

In the present study, the students' experience with gamified activities was favorable regarding knowledge improvement, feedback, challenge and goal clarity but moderate in terms of concentration, control, immersion and social interaction. In our content design, cooperative activity and the internal community of players were not supported. Opportunity for the interaction of learners considered only through the class group on the WhatsApp. Also, despite being satisfied with being involved in the game, students expressed less satisfaction with the emotional and visceral immersion. Generally, this issue can be caused by the limitation of gamification in using game elements and creating immersion (38). In this regard, Landers states that immersion in a three-dimensionally designed laboratory environment in a serious game is different from the two-dimensional environment of a laboratory containing a symbol of chemical substances and their composition in a simulation game (30).

The present study data show that students' experience with feedback, focus and challenge in the gamified content significantly correlates with their learning. In other word, students learn more when they perceive receiving immediate feedback, gaining points, and being aware of their progress. Additionally, their focus on the game and the absence of distractions in gamification, along with the presence of clues embedded in the game to assist them in solving challenges and understanding new concepts at their own pace, all contribute to their enhanced learning experience. This issue shows the importance of paying attention to these factors in the design of educational games. These findings are consistent with the experts' opinion that instant feedback is the second key principle in gamification (25). Also, it has been stated that extended feedback increases the participant's experience (39). Points, badges, and scoreboards are all critical elements of feedback that encourage users to cooperate, engage, and interact more (25). Designing different tasks in the game with increasing difficulty or time pressure can be another essential element in the design. Challenging yet specific goals can motivate people to take action and motivate their level of performance to seek strategies to improve, which can be explained by self-regulation theories (23).

One of the present study's limitations is that it was conducted during the Covid-19 pandemic. Hence students could not attend the university to control or accurately measure the duration of using the content. Other factors, such as students' prejudices about using games for learning, little experience in using digital games, and the volume of academic activities at the time of conducting the study, may influence students' optimal use of the content. Some studies have reported the different effects of gamification in boys and girls, which was not investigated in our research.

Conclusion

The study suggests that gamification can effectively improve the attitude of undergraduate students of medical sciences towards learning statistics. Moreover, gamified learning activities have been found to yield similar results to conventional learning activities in electronic learning environments, making it a time-efficient solution for managing large populations of learners without requiring direct instructor involvement. To optimize the gamification design for better statistics learning outcomes, it is recommended to focus on feedback, challenge, and concentration elements. Future studies can improve the accuracy of the results by increasing sample size and randomly assigning participants to the groups. Additionally, based on our experience the use of gamification promoting for adult learners may require socio-cultural readiness, awareness, and encouragement of both students and teachers.

Acknowledgements

The authors would like to thank all students who participated in the study. This research environment was health faculty of Guilan University of Medical Sciences and the authors would like to acknowledge the managers of Guilan University of Medical Sciences for their cooperation in making the study possible. In preparing some parts of the gamified content, the free templates created by Allison Nederveld and Sarah Hodge were used, and the authors thank them for this. The present work was carried out as the master science thesis of the second author under support and the auspices of Shahid Beheshti University of Medical Sciences.

Authors' Contribution

Conceptualization and Supervision: M.Kh and A.A; Methodology and Data collection and analysis: A.A; Investigation, Data interpretation, Writing – original draft, and Writing – review & editing: M.Kh, A.A and M.T; Funding acquisition and Resources: M.Kh.

Conflicts of Interest: None declared.

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