Original Article

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Design and Effect of Neurosurgical Educational Software Using Gamification on Students' Learning and Motivation

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Abstract

Introduction: Gamification is an innovative learning approach that, when combined with technology, aligns well with students' preferences. Recognizing the necessity of employing effective educational methods in surgical team training, this study aims to examine the impact of gamification-based educational software on students' learning and motivation in the surgical technology field.

Methods: This study was conducted as a quasi-experimental single-group pre-and post-test design in Iran in 2023. The study sample comprised 40 undergraduate students majoring in surgical technology, selected through a census method. The educational software is designed according to the nine principles of the model of Karl Kapp and Sharon Buller, using the mechanics, dynamics and aesthetics (MDA) framework. After implementation, the software's impact on students' learning and motivation was assessed. The students' learning levels before and after using the educational software were evaluated using a multiple-choice test. To measure students' motivation, a researcher-developed questionnaire was utilized. The Shapiro-Wilk test was used to check the normality of the distribution of the studied variables. Through SPSS version 26, descriptive statistics such as frequency, percentage, mean, and standard deviation were analyzed along with inferential statistics, including paired t-tests.

Results: Among the participants, 55% were female, and the sample had a mean age of 22.30±0.99 years. A significant difference was observed between the mean learning scores before and after using the educational software (10.43±4.38 vs. 21±4.11, P<0.001). The motivation level of the students showed a significant increase.

Conclusion: Based on the results of this study, gamification-based software has led to improved learning and increased motivation among students in surgical technology.

Keywords: Software designs, Gamification, Learning, Motivation, Neurosurgery

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Introduction

Neurosurgery, specifically brain and nerve surgery, is one of the most challenging and delicate surgical procedures (1). Medical errors within the surgical team can lead to irreversible complications such as mortality, iatrogenic diseases, and long-term post-neurosurgical complications (2). Surgical teams involved in neurosurgical procedures require fundamental surgical skills and a profound understanding of neuroanatomy and clinical manifestations of diseases (3). Despite the rapid advancements in

surgical technology, surgical team training has been progressing much slower (4). One of the most significant challenges in educating surgical technology students is providing effective training that ensures optimal clinical services (5). In the surgical environment, where conditions change every second, surgical technologists must be trained efficiently to tackle the upcoming challenges effectively (6). With the emergence and progress of new technologies, the learning needs of digital-era learners have also transformed, rendering traditional teaching methods less effective (7).

Integrating technology into the educational process proves instrumental in meeting the requirements of the new generation, and one of the most recent technologies involves incorporating gamification techniques into electronic learning environments (8).

The concept of gamification was first introduced by Nick Pelling in 2002 and has recently gained widespread popularity (9). Studies indicate that this instructional method has increased tenfold in the past five years (10). Gartner, the company, defines gamification as using game elements in non-game environments (11). Implementing gamification in e-learning engages learners, enhances motivation, and improves student learning outcomes (12). This active and innovative learning approach aligns well with the learning preferences of medical students (13).

Gamification offers numerous advantages for healthcare service providers, including increased knowledge and job skills, the ability to repeat learning experiences, utilization in adult education, facilitation of the teaching-learning process, feedback provision, enhanced interaction between educators and learners, creating opportunities for participation and engagement, and boosting learners' interest and motivation (14). Increasing motivation also enhances the overall learning outcomes of learners (15). Motivation refers to an individual's inclination towards success and engagement in an activity, where success depends on an individual's ability and effort (16). According to studies, traditional teaching strategies cannot solve learners' lack of motivation (17). By incorporating various game elements, gamification significantly impacts learners' motivation (18). While many elements are introduced in effective gamification design, PBL (points, badges, and leaderboards) remains the most popular (19). One of the foundational theories explaining how gamification works in creating motivation is the self-determination theory presented by Ryan and Deci in 2000 (20). This theory focuses on three major psychological factors that lead to enthusiasm and motivation for tasks: competence, which refers to an individual's ability and power to adapt to conditions and adjust their effort and skills according to the difficulty level of the challenge; relatedness, which deals with changes in an individual's behavior concerning others and within social contexts; and autonomy, which emphasizes an individual's right to choose and decide without external pressures and constraints (21).

A review of related literature demonstrates the positive outcomes of gamification in various fields of the medical sciences (14). For instance, gamification in neurosurgery education improved motivation and performance among surgical residents. Learners in gamified environments exhibited higher speed and fewer errors than the control group (22). Another study conducted on health, laboratory sciences, and medicine, students showed higher motivation and learning levels in psychology education using gamification methods (23). Examination of students' feedback and electronic learning management system data indicated that gamification is an appropriate strategy for enhancing motivation among nursing students, although further studies are needed (24). Also, one study indicates improved learning among surgical technology students using gamification-based educational applications in heart surgery courses (25). Although adult education gamification studies are increasing, many questions remain unanswered (26). For instance, there is still uncertainty regarding gamification's effectiveness in various contexts and subject areas, and its effect on motivational outcomes has not remained consistent over time (27, 28). Therefore, due to the insufficient evidence and the lack of attention given to the motivational components and player types of surgical technology students, the current study aims to design and investigate the effect of gamification-based neurosurgery software on the learning and motivation of surgical technology students at the Iran University of Medical Sciences (Tehran, Iran).

Methods

Study Type

The present study was a quasi-experimental single-group pre-post-test design.

Participants

The study was conducted on 40 undergraduate students in the operating room department at the Iran University of Medical Sciences. A gamified educational intervention was conducted in 2023

between May and July. The sampling method used was census sampling.

Inclusion and Exclusion

The inclusion criteria for this study were undergraduate students of the 6th and 8th semesters of surgical technology in the second semester of the academic year 2022-2023 who had successfully passed the theoretical courses on neurosurgery (offered in the 5th semester), expressed willingness to participate in the study, had not previously received training in gamification, were not guest or transfer students, and had access to a personal computer or smartphone. The exclusion criterion for the study was the failure to complete the software stages and questionnaires.

Design and Development of Educational Software

In this study, we applied the nine principles of effective educational game design proposed by Karl Kapp and Sharon Boller (29) to design and develop educational software for teaching neurosurgery techniques. This web-based software (https://neuroplay.ir) is versatile, compatible with various mobile phones and computers, and can be run on any operating system and screen size.

The stages are as follows:

Stage 1: Introduction and Familiarization with Gamification Fundamentals

In this stage, a deep understanding of the principles and concepts of the gaming and gamification domain was achieved through research, literature review, studying library resources, and conducting research studies.

Stage 2: Playing and Evaluating Educational Games

In this stage, educational games within the field of medical sciences (both domestic and international) were studied and evaluated. Technical and graphic design, game implementation platforms, educational content, etc., were all considered.

Stage 3: Exploration of Educational Games

During this stage, efforts were made to evaluate software and platforms based on gamification in medical sciences, especially focusing on their components and frameworks. The aim was to use the results and experiences from previous studies in the software design.

Stage 4: Defining the Learning Foundation and Initiating the Educational Design Process

Setting Objectives

In this stage, educational objectives were defined, and questions and questionnaires tailored to these objectives were designed and sent to the expert panel for evaluation.

Analysis of Learners' Characteristics

In this stage, demographic profile forms were completed by the participants. Additionally, the Hexad player types questionnaire was used to analyze the players' personalities and the specific components that should be considered alongside general components in game design (30). The predominant personality traits among the students were Philanthropists, free-spiritedness, and achievement. The components that received more attention alongside the general components included:

- **Philanthropists:** Assisting others and sharing knowledge; collecting medals; awareness of game objectives.
- **Free-spirited:** exploration, unlocking, the right to choose, being amazed.
- **Achiever:** challenges, certifications, learning opportunities, stages.
- **General:** game guidance and teaching to learners; feedback; theme; time constraints; rewards; storytelling; replay ability; leaderboard.

Fifth Stage: Linking Learning with Game Design

During this stage, the precise content of the game design document was developed using the Mechanics, Dynamics, and Aesthetics (MDA) framework. This is framework, introduced by Hunicke and colleagues in 2004, is one of the most fundamental and widely accepted frameworks for game design. Mechanics refers to the game's rules and principles (such as challenges, chances, and feedback). Dynamics encompasses the events during gameplay, including narrative, emotions, and progression paths. Aesthetics involve the emotions and feelings a player can experience while playing the game. These elements are essential for understanding systemic thinking and the mutual effects of game elements in non-game contexts (31).

Type of Game: electronic and web-based that can be run on computers and smartphones.

Goal: The goal of the game is to become a professional surgeon's assistant in the field of neurosurgery by getting the highest score and successfully passing all the stages.

Dynamic: The main dynamic is solving the problem and answering the questions.

Game Mechanics or Rules

Game environment: In this game, by creating a user account, learners must be able to complete

each stage of the game, which is set based on the syllabus topics. The game consists of 9 stages; at the beginning, only the first stage will open, to begin with, and to open each stage, players need to successfully complete the previous stages by at least capturing one light. On the left side, the game narrator guides the learners to make decisions in the game environment.

Perform the steps: To pass each stage, at least one light equal to 30% of the points of that stage must be obtained. Otherwise, learners have to play the stage again from the beginning. The game was designed so that if the players needed to leave the game in the middle of each stage, they could answer the questions after returning to the game. Learners received feedback immediately after answering each question, and the correct answer was displayed.

Type of questions: To answer each question, the question was displayed first, and after clicking on "show options", the options containing correct and incorrect answers were displayed. After selecting the desired option or options, if the learner wants to correct his answer, he will click "again". If the answer is approved by clicking on "confirm," the answer will be validated, and the score will be calculated. There was a time limit to answer the questions.

Game Elements Used

- Point
- Story
- Time limitation
- levels
- leaderboard
- Badge
- Feedback
- Replay
- Competition
- Avatar

Educational content: The educational content related to neurosurgery techniques for the brain, spinal cord, and peripheral nerves was developed by the sources outlined in the undergraduate surgical technology curriculum (3, 6, 32, 33). The stages of the curriculum encompass basic and advanced concepts, including anatomy, pathology, diagnostic procedures, surgical readiness, instruments and equipment, peripheral nerve surgery, brain surgery, and spinal surgery. The content of the course materials, instructional videos, and specialized terminology were also compiled at this stage. The faculty of the operating room department approved the validity of the educational content.

Sixth Stage: Considering Points and Rewards

In this software, various elements were utilized as rewards, including badges (earned by obtaining 95% of the points in each stage), a three-star system (based on the percentage of correct answers to questions), a score table (for comparing scores), cash prizes (awarded to the top 4 scorers), and certificates (for all individuals who successfully completed the game stages).

Seventh Stage: Prototype Development

In this stage, the game design document and the research team's ideas were shared with the programming team. Together, they collaborated to create the initial version of the software, aligning the game concept with the development process.

Eighth Stage: Playtesting and Iteration

Playtesting refers to the actions taken to improve the game until it reaches the desired state. After creating the initial prototype, the design team thoroughly reviewed the software. The entire process, from start to finish, was meticulously examined, and any necessary modifications were made by both the programmers and the design team. Furthermore, the software was made available to five target users to uncover and rectify any errors or issues in the design that might have gone unnoticed by the designers and programmers.

Ninth Stage: Game Development and Implementation, Iteration, and Deployment

In this stage, one of the researchers visited the research environment and conducted an orientation session on how to use the software and address potential questions from students. Subsequently, an information group was formed on a virtual network (Telegram), accessible to all students, to facilitate necessary communications. It's worth noting that an instructional video on how to use the software and supplementary information were provided within the group for students to refer to if needed. Students were then requested to message the researcher if they were interested in participating, and they would receive the link immediately. Students were given a two-month timeframe to complete the software. During the intervention, the researcher acted as a facilitator, providing necessary guidance and addressing any issues that arose while using the software. Since this software was entirely electronic and the instruction was provided virtually, students were self-directed in progressing through the stages, affording them the utmost flexibility in terms of time and location. After receiving the link and registering on the website, the

students first participated in a pre-test to assess their initial knowledge. A week after completing the stages, they were given a post-test for evaluation. The samples were given the researcher's motivation questionnaire once they had finished using the software.

Data Collection Tools

Player Type: The hexad scale was used to assess the player type, introduced by Marczewski and colleagues in 2016 (30). This questionnaire consists of 24 items and employs a 5-point Likert scale (ranging from "strongly agree" with a score of 5 to "strongly disagree" with a score of 1). The hexad scale categorizes players in gamified environments into six personality types: philanthropists, socializers, free spirits, achievers, players, and disruptors. Each player type is assigned four specific questions, and the category with the highest score indicates the dominant player's personality.

Assessment of Learning: The researcher-designed test comprised 30 multiple-choice questions based on the reference sources of the undergraduate surgical technology curriculum. The questions covered topics related to the stages of surgery, including anatomy, clinical manifestations, diagnostic procedures, surgical preparedness, tools and equipment, peripheral nerve surgery, brain surgery, and spinal surgery. Each correct answer received one point, while incorrect or unanswered questions were scored zero. The maximum attainable score was 30, and the minimum was 0. Pre-test questions were completed before the educational intervention, and post-test questions were completed one week after the intervention.

Assessment of Motivation: A researcher-designed motivation questionnaire consisting of 10 items was provided to the students. The motivation questionnaire used a 5-point Likert scale (ranging from 1 for "completely disagree" to 5 for "completely agree"). Scores between 10 and 30 indicated low motivation, 31 to 40 indicated moderate motivation, and 41 to 50 indicated high motivation. The researcher's motivation questionnaire was provided to the samples after they completed the software's steps to measure the software's impact on students' motivation.

Validity and Reliability

Player-type questionnaire: The reliability and validity of this questionnaire in Iran were confirmed by Abdollahzade and Jafari (34), who obtained a Cronbach's alpha coefficient of 0.72. This study assessed internal consistency and reliability using Cronbach's alpha coefficient. The reliability coefficients were determined to be 0.856 for this questionnaire.

Learning question: To ensure content validity, the content coverage and relevance of the question to the primary objectives were drafted according to the initial blueprint and Content Validity Ratio (CVR) and Content Validity Index (CVI) indices approved by 10 experts in the fields of surgical technology, medical education, and e-learning. We asked an expert to rate each of the items as ''essential'', ''useful but not essential'', or ''not essential''. A weighted value was assigned to each rating. Responses from all panelists were pooled, and the number indicating ''essential'' for each item was determined. The value of the content validity ratio for 10 experts in the Lawshe table is considered to be at least 0.62. Items that did not reach this threshold were deleted from the final questionnaire. This ratio was in the range of 0.8 to 1 for the final questionnaire items for the CVR. For the Content Validity Index (CVI), the three criteria of relevance, simplicity, and clarity were examined separately by experts in a four-part spectrum for each of the items (1: unrelated, 2: somewhat relevant, 3: relevant, and 4: completely relevant). The CVI score was calculated by summing the positive scores for each item ranked 3rd and 4th over the total number of experts. Acceptance of items based on CVI was higher than 0.79 (35, 36). Construct validity was confirmed by verifying the formulation of questions and options for each question based on the Millman checklist. A Cronbach's alpha coefficient of 0.870 was obtained for this questionnaire.

Motivation Questionnaire: The content validity (CVR and CVI indices) of this questionnaire was confirmed by 10 experts in surgical technology, medical education, and e-learning. The value of the content validity ratio was in the range of 0.8 to 1 for the questionnaire items. The content validity index of all questionnaire items was above 0.79. Cronbach's alpha coefficient was determined to be 0.948 for the motivation questionnaire.

Statistical Analysis: The results of the Shapiro-Wilk test indicated that the distribution of the study variables is normal (Table 1). Parametric tests were employed for data analysis. Data were analyzed using descriptive statistics such as frequency, percentage, mean, and standard deviation, as well as inferential statistics, including paired t-tests, in SPSS version 26. A significance level of less than 0.05 was considered.

Table 1: Shapiro-Wilk test to determine the normality of Variables

Variable's	Mean±SD	Shapiro Wilk statistics	P
Learning (before)	10.43±4.38	0.960	0.168
Learning (after)	21±4.11	0.950	0.079
Motivation	39.53±8.34	0.931	0.091

Table 2: Types of Player Personality Among Surgical Technology Students

Domain	Score	N (%)	Mean±SD
Philanthropists	Low (scores between 4 to 12)	5 (12.8%)	11±1.73
	Average (scores between 13 to 16)	13 (33.3%)	15.62±0.87
	High (scores between 17 to 20)	21 (53.8%)	19.10±1.18
	Total	39 (100%)	16.90±3.02
Social	Low (scores between 4 to 12)	8 (20.5%)	9.38±1.30
	Average (scores between 13 to 16)	17 (43.6%)	14.76±1.09
	High (scores between 17 to 20)	14 (35.9%)	18.79±1.42
	Total	39 (100%)	15.10±3.67
Free-spirited	Low (scores between 4 to 12)	2 (5.1%)	11±1.4
	Average (scores between 13 to 16)	12 (30.8%)	15±1.35
	High (scores between 17 to 20)	25 (64.1%)	18.40±1.12
	Total	39 (100%)	16.97±2.41
Disrupters	Low (scores between 4 to 12)	19 (48.7%)	9.63±2.31
	Average (scores between 13 to 16)	16 (41%)	14.44±1.15
	High (scores between 17 to 20)	4 (10.3%)	18.50±1.29
	Total	39 (100%)	12.51±3.56
Achiever	Low (scores between 4 to 12)	1 (2.6%)	11±0
	Average (scores between 13 to 16)	12 (30.8%)	14.75±1.05
	High (scores between 17 to 20)	26 (66.7%)	18.62±1.20
	Total	39 (100%)	17.23±2.36
Player	Low (scores between 4 to 12)	2 (5.1%)	12±0
	Average (scores between 13 to 16)	21 (53.8%)	14.48±1.08
	High (scores between 17 to 20)	16 (41%)	18.75±1.29
	Total	39 (100%)	16.10±2.56

Table 3: Comparison of the Mean Scores Obtained from Questions Related to Learning Among Surgical Technology Students Before and After Training

Time	N	Mean±SD	Test statistic*	P
Before training	40	10.43±4.38	t=-11.51	<0.001
After training	40	21±4.11		

*t: Paired-Samples T Test

Table 4: Motivation Level of Surgical Technology Students

Score	N (%)	Mean±SD
Low (scores between 10 to 30)	6 (15%)	25.17±5.64
Average (scores between 31 to 40)	15 (37.5%)	36.47±3.04
High (scores between 41 to 50)	19 (47.5%)	46.47±2.72
Total	40 (100%)	39.53±8.34

Results

Based on the data collected from 40 research participants, 55% (22 individuals) were female, and 45% (18 individuals) were male. The average age of the sample was 22.30±0.99. As observed in Table 2, the level of gaming personality traits among surgical technology students has been significantly high in the areas of altruism, freedom, and achievement.

As observed in Table 3, there was a statistically significant difference in the mean scores obtained from the questions related to learning among surgical technology students before and after training (P<0.001), with the mean scores approximately doubling.

As indicated in Table 4, after the educational intervention, the level of motivation among surgical technology students was predominantly high (19 individuals, equivalent to 47%) and moderate (15 individuals, equivalent to 37.5%).

Table 5: Mean and Percentage of Students' Responses to the Motivation Questionnaire

Motivation Item	Strongly disagree (1)	Disagree (2)	No opinion (3)	Agree (4)	Strongly agree (5)	Mean±SD
	N (%)	N (%)	N (%)	N (%)	N (%)	
1. By earning a higher score, i gain a higher level of scientific competence.	1 (2.5%)	0	8 (20%)	17 (42.5%)	14 (35%)	4.08±0.888
2. Completing various stages leads to my satisfaction.	0	2 (5%)	7 (17.5%)	15 (37.5%)	16 (40%)	4.12±0.883
3. Receiving immediate feedback boosts my motivation to rectify mistakes.	0	2 (5%)	7 (17.5%)	18 (45%)	13 (32%)	4.05±0.846
4. I strive to improve my performance by comparing my rank in the score table (leaderboard).	1 (2.5%)	3 (7.5%)	5 (12.5%)	14 (35%)	17 (42.5%)	4.08±1.047
5. Completing challenges gives me greater self-confidence in the operating room environment.	2 (5%)	2 (5%)	13)32.5%)	12 (30%)	11 (27.5%)	3.70±1.091
6. By earning a higher score, I acquire more practical competence.	1 (2.5%)	2 (5%)	9 (22.5%)	18 (45%)	10 (25%)	3.85±0.949
7. Using the software motivates me to put in more effort for personal and professional growth.	2 (5%)	1 (2.5%)	12 (30%)	11 (27.5%)	14 (35%)	3.85±1.099
8. Completing the stages increases my interest in participating in surgeries.	3 (7.5%)	1 (2.5%)	10 (25%)	13 (32.5%)	13 (32.5%)	3.80±1.159
9. I put all my effort into successfully completing my learning process.	2 (5%)	1 (2.5%)	9 (22.5%)	13 (32.5%)	15 (37.5%)	3.95±1.085
10. Implementing this teaching method enhances my self-directed learning.	1 (2.5%)	2 (5%)	8 (20%)	12 (30%)	17 (42.5%)	4.05±1.037

The mean and percentage of students' responses to the motivation questionnaire are shown in Table 5.

Discussion

The results of this study demonstrate that game-based educational software has impacted the learning outcomes of surgical technology students, leading to increased learning. These findings align with the research conducted by Salehinia and colleagues (2023), where they designed, implemented, and evaluated a game-based educational application for cardiac surgery on surgical technology students. The results of this study have shown that with the advancement of technology, the use of innovative methods such as gamification in education leads to improved learning outcomes and enhances the effectiveness of education for surgical technology students (25). Furthermore, the results of this study align with the research conducted by Mosalanejad and colleagues (2018), which aimed to investigate the effectiveness of game-based education on the learning indices of nursing students. The findings of their study demonstrated that gamification, by creating an interactive and engaging environment, significantly impacts students' learning outcomes (37). Additionally, our study findings align with the research conducted by McAuliffe and colleagues (2020). Their study aimed to assess the feasibility and effectiveness of game-based education for general surgery residents, revealing that using this instructional method led to enhanced learning outcomes (increasing the average scores from 28 to 43) (38).

Furthermore, the study by Eslami and colleagues (2020), which aimed to design a game-based educational application for basic drug information targeted at pharmacy students, demonstrated that this application served as a useful tool for learning drug-related information. This instructional method can be employed across various academic disciplines (39). The traditional roles of teachers and students in teaching and learning have changed nowadays, emphasizing the active participation of learners. When students actively engage in their learning process and construct meaning proactively, a better and deeper learning experience is achieved (40). Therefore, gamification is among the most active and student-centered educational approaches. It enhances the quality of learning by creating a dynamic environment with visual appeal.

The results of this study also indicate that most surgical technology students (85%) had a high motivation for learning through gamification. Numerous studies have demonstrated that incorporating game elements enhances student motivation. The findings of Mosalanejad and colleagues (37), who conducted a study to evaluate gamification in the field of psychiatry on a group of medical and paramedical students, showed that when educational content is combined with appropriate game elements, it significantly boosts learners' motivation (mean>2.5) (21). Furthermore, Permanasari and colleagues (2021) conducted a study in Indonesia to teach anatomy to medical science students through gamification.

They concluded that educational media based on gamification, incorporating elements such as rankings and scores, significantly enhances students' motivation (41). The study conducted by Felszeghy and colleagues (2019) aimed to examine the impact of the gamified online platform (Kahoot) on medical and dental students in the histology course. The study demonstrated that gamification increased motivation for learning in 77.5% of the participants (42). Based on the findings of our study and in line with our self-determination theory, we found that learners, by answering questions and facing challenges presented in the educational software and progressing through stages to acquire the necessary knowledge, felt a sense of competence and capability in the scientific (77.5%) and practical (70%) aspects. They expressed that the software effectively increased their participation in the operating room environment (65%). Regarding learner interaction, due to the elements present in gamification, such as immediate feedback (77%) and a leaderboard (77.5%), participants made efforts to improve their performance and rectify errors. Furthermore, learners expressed that they put in their utmost effort to succeed in the learning process within the software (70%). Regarding autonomy, given the flexibility of time and place in the software and its student-centered nature, learners could guide their learning process without external pressure or constraints (72.5%). Despite the positive effects of gamification in health profession education, some studies have also pointed out unintended consequences (10). For example, some studies have mentioned that certain components, like competition and scoring tables, might decrease motivation for some students (43, 44). The results obtained in these studies could be because students with weaker performance may feel discouraged and demotivated when they see their low rank and score compared to others. Another reason for decreased motivation could be the lack of attention to motivational components tailored to learners' preferences and personality traits. The findings of the present study indicated that elements such as points (77.5%), immediate feedback (77%), leaderboards (77.5%), stages (77.5%), and challenges (57.5%) were effective in increasing student motivation. Therefore, considering that most studies demonstrate the positive impact of gamification on learners' motivation levels, it can be concluded that when educational content is combined with appropriate game elements, and learners have control over their learning process, they will exhibit high motivation.

According to the results of the present study, the students' predominant personality traits were Philanthropists, free-spiritedness, and achievement. We tried to use game components suitable for the type of player in the gamification design. In various studies, students' game personalities have been investigated. For example, in a study by Kocadere and Çağlar (2018), player types were determined as killer, achiever, explorer, and socializer (45). In the study by Krath and von Korflesch (2021), athletes and philanthropists were the most dominant (46). Certainly, according to demographic characteristics (such as age, gender, field of study, etc.) and educational content, students have individual player types. It is important to pay attention to the personality characteristics of students in gamification design to create motivation and better learning.

Strengths and Limitations

In this study, we endeavored to design game-based educational software in an effective and student-centered manner, considering the personality traits of widespread gamers and the nine gamification principles. The web-based educational software we developed was compatible with various operating systems. We also extracted several motivational components and their impact percentages on students. It was a prerequisite for the participants to have completed a comprehensive theoretical unit on brain and nerve surgery before engaging with the software. The research sample was limited to 6th and 8th-semester surgical technology students at Iran University of Medical Sciences. Also, one of the limitations of our study was that it was carried out in a single group.

Recommendations for Future Studies

Future studies can be conducted with a larger sample size and the inclusion of a control group. Additionally, it is possible to utilize game-based software in blended learning and face-to-face instruction.

Conclusion

The results of this study demonstrated that game-based software significantly influenced the enhancement of learning and increased motivation among surgical technology students. In today's world, technology has impacted all fields, and education is no exception. Technology creates new opportunities for educating digital-native students. Gamification is an innovative and active educational approach that optimizes and makes learning engaging, offering substantial potential for fostering self-directed learning in learners. Integrating technology and gamification

elements in e-learning environments enhances the enjoyment of learning and improves learners' motivation, potentially positively affecting personal and professional development. Educational specialists and designers can apply the findings of this research in all medical-related fields, especially surgical technology. Further studies in this area are warranted to explore its full potential.

Ethical Considerations and Acknowledgments

This research was conducted under the ethical code IR.IUMS.RES.1402.102, approved by the Operating Room Department of the Iran University of Medical Sciences, as part of a Master's thesis. The financial support provided by the Research Deputy of this university is gratefully acknowledged. The researchers now express their sincere gratitude to the students who participated in this study.

Authors' Contribution

Conceptualization and supervision: S.H. and M.S. Data collection: M.S.; statistical analysis: N.A.A.; investigation: M.S.; methodology: F.A. and M.S.; resources: M.S.; software: M.S. and S.H. The final manuscript has been read and approved by all authors, who agree to be accountable for all aspects of the work.

Conflict of Interest

The authors declare no conflicts of interest.

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