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Personalized educational video games: Keys to success in the classroom

ألعاب الفيديو التعليمية المخصصة: مفاتيح النجاح في الفصل الدراسي

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Abstract

This research explores strategies to adapt educational video games for primary school students with diverse abilities, aiming to enhance their learning experiences and achievements. The mixed-methods study involved 25 students from Saudi Arabian primary schools and compared the effectiveness of adaptive learning algorithms and differentiated instructional strategies. Results showed that adaptive educational games increased student engagement and comprehension, attributed to factors like enthusiasm, graphics, and immediate feedback. Concerns included technical issues, stability, and lack of clear instructions. The findings align with previous research, emphasizing the positive impact of personalized game-based learning environments on student motivation and academic outcomes. The study offers valuable insights for educators and policymakers seeking to implement adaptive educational games effectively in primary education.

Keywords: Games for education, personalization, learning achievements, primary school, student skill diversities.

الملخص

يستكشف هذا البحث استراتيجيات تكييف ألعاب الفيديو التعليمية لطلاب المرحلة الابتدائية ذوي القدرات المتنوعة، بهدف تعزيز تجاربهم التعليمية وإنجازاتهم. شملت هذه الدراسة الكمية والنوعية 25 طالبًا من طلاب المرحلة الابتدائية في المملكة العربية السعودية، وقارنت فعالية خوارزميات التعلم التكيفي واستراتيجيات التدريس المدمجة. أظهرت النتائج أن الألعاب التعليمية التكيفية زادت من تفاعل الطلاب وفهمهم، ويعزى ذلك إلى عوامل مثل الحماس والرسومات والتغذية الراجعة الفورية. وشملت المخاوف المشكلات التقنية، والاستقرار، ونقص التعليمات الواضحة. تتوافق النتائج مع الأبحاث السابقة، مؤكدةً على التأثير الإيجابي لبيئات التعلم الشخصية القائمة على الألعاب على تحفيز الطلاب ونتائجهم الأكاديمية. تقدم الدراسة رؤى قيّمة للمعلمين وصانعي السياسات الذين يسعون إلى تطبيق الألعاب التعليمية التكيفية بفعالية في التعليم الابتدائي.

الكلمات المفتاحية: الألعاب تعليمية، تخصيص، إنجازات تعليمية، مدرسة ابتدائية، تنوع مهارات الطلاب

Introduction

Education video games have been developed over the last few years as an effective solution to fuel the learning process, especially in primary school education. These games are useful in providing students with rich material in terms of concepts they can understand and improvement of their thinking skills. However, one of the main barriers to the effective use of educational video games is the ability level differences

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among learners in a classroom. This issue is more common in Saudi Arabia since the education system has adopted a new system of education to meet the new world standard.

The purpose of this research is to establish approaches that can be used to enable educational video games to support students with varying learning ability levels in primary schools in Saudi Arabia. Customized game content and functional capabilities should be set by the game type and learning level of the student; in doing so, the training process will be enriched, and the student himself will engage in the learning process. This study explores a variety of methods of customization, including learning algorithms and the differentiation of instruction, to determine the effectiveness of the performance of students. As such, this research tries to adopt a mixed-method approach whereby both qualitative and quantitative data will be used to establish the effectiveness of the above-mentioned adaptive strategies. The knowledge gathered will be valuable to the existing literature on educational technology, and specific guidelines on how to incorporate AEGA into Saudi primary schools will be presented. Therefore, the purpose of this research is to contribute to the understanding of how personalization technologies might help in creating the best learning environment for everyone.

The incorporation of educational video games in primary education has been a subject of research and has established that such adoption leads to improved student engagement and learning achievement. Chen et al. (2021) study explains how video games can help enhance learners' solution-finding abilities and critical thinking since they are effective in helping learners grasp concepts that they learn in the classroom and make learning a fun process. Equally, Singh (2021) demonstrated that educational games brought a positive change in the mathematical performances of elemental students; this they attributed to the game's flexibility concerning time and learning patterns. According to Yolac (2021), narrative-based learning is an education approach that makes use of the story element in games to capture students' attention and help them understand concepts that may seem complex by providing real-like experiences. Likewise, a study by Leite in (2019) focused on the concept of content customization in educational video games when the authors concluded that such content greatly increases the learners' motivation levels and the overall learning rates gained in the process. This indicates the necessity of matching the content of the games to individual students' abilities and preferences to reproduce teaching outcomes. Collectively, these results suggest that learner and curriculum-specific educational video games are effective in primary education, and their application should be encouraged in an effort to meet the different learning needs and improve achievement in academic settings.

Objectives:

1. To examine some of the challenges faced when making educational video games with adaptations to different ability levels to be addressed.
2. To review the effect of the level of customization on the learning outcome.
3. To familiarize with guidelines for its proper implementation in Saudi primary schools.

Literature review

Video games have become popular and are effective means in the delivery of lessons to students in their early academic years. The growing body of literature shows that much has been done in identifying how these technologies can be used in catering for students' needs, especially the variation in learners' abilities.

A study by Alenezi (2024) revealed that when learning is applied in the context of play, through games, there was a great enhancement of the math performance among the Saudi primary school learners. In a study conducted with 120 students at different grade levels, they discovered that through the approach of varying difficulty level, there was a 27% increase in the problem solving skills than that of the normal teaching technique. This can be in concordance with the current study that focuses on the use of adaptation in the context of students of different abilities, where the study shows that differentiation is very effective.

The use of artificial intelligence in educational games has brought a dramatic change in the way personalization is done. Strielkowski et al. (2024) sought to elucidate on the possibility of utilizing learning algorithms to identify the performance of students and adapt the game level of difficulty. In their study with 85 elementary students, they found out that addictiveness in progression led to increased engagement level and knowledge gain as opposed to non-adaptive games. Nevertheless, they pointed out methodological

restrictions related to the identification of some learning styles, indicating that the use of both adaptive learning and teacher-driven adjustments could be the most effective.

Some of the researchers also commented about the implementation issues when it comes to educational games. In a study done by Kaimara et al. (2021) covering 15 international schools, the author discussed various challenges of implementing educational games. These included teacher technology proficiency, curriculum alignment problems and issues on cultural acceptability. In particular, in relation to the Saudi Arabian context, Kaimara pointed out that adaptive educational game presuppose a high level of technical support that can hardly be provided in all learning environments; teachers' training is also needed. This explains why it is necessary to take into account real-world factors of implementation in addition to the theoretical advantages.

The debate around educational games extends to their assessment mechanisms. Gómez-Álvarez et al. (2017) argued against the effectiveness of game-based constructivist assessment strategies in the assessment of deeper conceptual knowledge. In her study, comparing the traditional assessment and game-based assessment with forty primary Saudi students, Gómez-Álvarez et al. (2017) identified a difference in the interaction of students at different ability levels with the elements of assessment within the game. Lower achievers tended to emphasize on the game aspects rather than the content as compared to higher achievers who were strategic in their approach to learning objectives. This implies that adaptation strategies have to take into account not only the difficulty levels of the content but also the type of assessment for learning that will be used to monitor learning achievement at different levels of learning.

The literature also shows that there is a shift to cultural aspects in designing of games (Kaimara et al., 2021). The games designed for western students may include features that may not be familiar to the Saudi Arabian students or may contradict culture. This cultural aspect puts another layer into the adaptation process since content, images, and even storyline used have to be sensitive to Saudi Arabia culture and relevant to its learners (Singh, 2021).

However, the literature presented in this paper testifies to the effectiveness of adaptive educational games in the improvement of results. The possibilities of individualization, which modern technologies provide, can be implemented in the process of education to a greater extent than it is possible with traditional methods. Singh (2021) also pointed out that the characteristic of educational games to be timeless and adaptable to time and learning patterns is advantageous for the diverse learners.

The present study will extend these findings by focusing on the implementation issues only and developing the strategies to adapt them in the context of Saudi Arabian primary schools. In this research, both qualitative and quantitative methods have been used in order to make practical findings to the existing literature on the adaptation of educational games for lower ability learners.

One of the research gaps that emerged relates to the use of adaptive educational games in Saudi Arabian primary school environment: culture, school facilities, and teaching practices in KSA may affect adaptive educational games adoption in some ways. This study aims to fill this research gap by offering context-related recommendations which is grounded on the international literature on the adaptation of educational games.

Materials and Methods

Research Design

The current empirical study uses mixed methods, in which quantitative and qualitative analysis is used to consider the impact of personalized educational video games. The first is a qualitative analysis of the content of participants' responses to feedback, while the other is a quantitative measure of mean differences of pretest and post-test scores. This approach helps to gather robust data to understand the effectiveness of adaptive educational video games for students with different learning abilities.

Participants

In the study, the participants were 25 primary school students and teachers from different schools in Saudi Arabia purposively targeted to comprise low, average, and high achievers. To guarantee that the outcomes

obtained would be relevant in a wide variety of learning environments, the sample comprised students with various learning capabilities.

Data Collection

A structured and closed ended questionnaire was used to elicit both qualitative and quantitative data from respondents. The survey included three questions of learning outcomes based on the quantitative approach, and five questions that addressed the experience of the students with feedback from custom educational video games based on the qualitative approach.

To address the instrument validity, the questionnaire was reviewed by three educational technology specialists as well as two primary education researchers in terms of content relevance, clarity, and comprehensiveness. To fine-tune the instrument, a pilot study was conducted with a sample of five primary students who were not part of the sample of this study; the pilot testing led to slight modification of the questions. Cronbach's alpha ($\alpha = 0.85$) which is above 0.70 was used to test internal consistency reliability of the quantitative items.

Pre and post-tests were designed based on the grade level content and were checked by the faculty members of the subjects to ensure that the content was valid. Through pilot testing, inter-observer reliability was established at 0.88 on test-retest basis of these instruments.

Procedure

The participants completed the questionnaire after the second week of using the educational video games that were developed according to the results of the participant observation. In this case, pre-and post-tests were also used to assess the impact of the intervention on the learning achievements. The pretest was given before the use of educational video games while the post test was conducted before the end of the two weeks.

Data Analysis

Qualitative Data Analysis

The data collected from the questionnaire were qualitative in nature and therefore were analyzed with the aid of content analysis. This method entailed a process where responses were assigned codes in order to identify significant themes and patterns. These themes formed the basis for content analysis to understand the students' experiences and perceptions of the developed customized educational video games.

Quantitative Data Analysis

The collected quantitative data were, therefore, analyzed using statistical measures such as mean, median, mode, range, variance and standard deviation. In addition, frequency distribution tables and histograms were constructed in an attempt to display the data.

Standard Deviation Formula

$$\sigma = \sqrt{\frac{\sum(x_i - \mu)^2}{N}}$$

This formula was computed utilizing the pre and post-test scores so as to see the amount of fluctuation in the learner's performance before and after the use of the educational video games. The most useful aspect of using the standard deviation is that it offers insights on the spread of scores and the stability of the learning outcomes.

Ethical Considerations

This study complied with the relevant ethical codes in order to safeguard the rights and welfare of all the subjects. First of all, participants and their guardians provided written and informed consent. This included

imparting to the participants the reasons for conducting the study, how the study would be done, the possible risks associated with the study, and the gains that the participants, the study, and the larger society were to derive from the study. Participants were also told that they had the right to withdraw from the study at any time without penalty. In this research, participants-maintained anonymity and confidentiality when being interviewed. All the identifiable information of participants was kept anonymous, and the data collected were only analyzed in a way that the participants could not be recognized. This was done by anonymising the records of data and publications by substituting the identities with codes or pseudonyms. In addition, precaution measures had also been taken concerning the use of participants in the study so as to avoid any harm or discomfort to the participants. The level of risk that accompanied the use of video games in the classroom was quite low, and the material used for the games was appropriate for ages and cultural sensitivity. In any case where a participant had any issues regarding any of the participants during the conduct of the study, help was offered to them. The patients and informants were asked for consent before being included in the study and the institutional review board approval was sought so as to meet all the ethical requirements of the study. This strong ethical review indicates that the research was conducted ethically and responsibly with much concern to the participants.

Results

Data Analysis

Qualitative Data Analysis

Teachers and students' feedback of the adapted video games were gathered and subjected to content analysis. Additional data was obtained from the questionnaire in form of open-ended questions, which allowed the respondents to provide elaborate views about their experiences. In this paper, such patterns are defined and their relation to the existing theories on education and technology adoption is discussed.

Qualitative Questions and Responses

1. What did you like most about the educational video game?

Some of the responses from students are as follows:
Engagement and Fun:

- Student A: "The challenges and levels were good because they kept me engaged and made learning enjoyable."
- Student H: "Actually, the game was fun and I wanted to continue with the game."

Visual and Audio Elements:

- Student M: "The colors and music were cool."
- Student N: "I enjoyed the characters they used such as animations and sounds."

Learning Reinforcement:

- Student E: "This game assist me to recall what was taught in the class."
- Student B: "In my opinion, the game helped me to comprehend the topic better."

General Responses:

Engagement and Fun: The students also showed frequent enthusiasm in the games; they described some of the features that made learning fun. Comments like "I like challenges and levels", "The game was enjoyable and entertaining, and I wanted to continue playing" are consistent with Flow Theory, where learners are challenged but can perform the tasks, and as a result, they are engrossed in the activity.

Multiple students expressed appreciation for the video/audio components of the games. The comment such as "I like the colors and music in it" and "I enjoyed animations and sound effect" supports Mayer Cognitive Theory of Multimedia Learning, which states that learning is optimum when both the visual and the audio channel are active, thus creating deeper cognitive processing of information.

Reinforcement: Some students understood the educational utility of the games in reinforcing lessons taught in class. The ideas like “The game made me to revise what was taught in the class” and “The game helped me understand the topic better” are in harmony with the principles of Constructivist Learning Theory, in which new knowledge is supplied to the learner and the construction of new knowledge is achieved through interaction with new information.

Themes:

Engagement and Motivation: The games encouraged long engagement time, which aligns with Self-Determination Theory since people will be motivated to perform an activity that satisfies competence and autonomy.

Graphics and sounds used in the games enhance its learning aspect in accordance with the Affective-Motivational Theory that embraces the role of motivational affect in learning.

Educational Value: It was established that the games contributed to learning concepts in a way that was in agreement with the Information Processing Theory since the computer games enriched learning through meaning-making encoding that was repeated.

2. What challenges did you face while playing the educational video game?

Responses from students included:

Technical Issues:

- Student B: "The game sometimes froze."
- Student H: "A lot of time was spent for it to get rolling."

Difficulty Levels:

- Student C: "Some parts were too hard for me."
- Student J: "It was too easy and not challenging."

Understanding Instructions:

- Student D: "The instructions were confusing."
- Student M: "Initially, I could not comprehend what I should do."

General Responses:

Challenges: Some of the students faced technical challenges that limited their work. Statements such as ‘’The game sometimes froze’’, ‘’It was slow to start’’ can be argued to belong to the Technology Acceptance Model, whereby perceived ease of use has a great impact on the uptake as well as the efficiency of the technology in use.

Difficulty Levels: Students also commented on difference in the level of difficulty which they encountered in the game, some of the levels were considered to be too hard while others too easy. This range of reactions depicts the Zone of Proximal Development of Vygotsky where learning is most effective when tasks are just beyond the reach of the learner but are still within the facilitation zone.

Comprehension: This is evident whereby some of the students failed to understand the instructions in relation to the game mechanics and goals. The comments like “the instructions were confusing” and “I was not sure what to do initially” are a clear indication that the instructional scaffolding is needed, as pointed out by Instructional Scaffolding Theory.

Themes:

Technical Difficulties: This was evident in technology factors that hindered participation, which is in agreement with Hew & Brush's (2007) study on the main barriers to educational technology integration that include technical challenges.

Appropriate Challenge Levels: The differences in the difficulty level reflect the main idea of the issue that is connected to the Adaptive Learning Theory, which has to do with the fit between the learning tasks assigned and characteristics of the learner.

Clarity of Instructions: The importance of clear guidance emerges as essential for optimal game experience, reflecting Cognitive Load Theory, which suggests that effective learning environments minimize extraneous cognitive processing.

3. How did the game help you learn better compared to traditional teaching methods?

Student responses included:

Interactive Learning:

- Student A: "I found that I was able to learn at a much faster pace because I could actually go out there and do things myself."
- Student L: "This was more of learning through practicing."

Visual Aids:

- Student F: "I think the pictures helped me understand."
- Student G: "This simplification was made easier by the animations."

Immediate Feedback:

- Student M: "I liked getting scores right away."
- Student R: "I knew whether I was right or wrong immediately."

General Responses:

The ability to play games was considered as a plus point because it involved the students in active learning. Such comments as "I was able to learn faster because I was able to attempt things on my own" and "It was more like a process of learning through practice" are a clear reference to experiential learning theory as it holds with the notion of transformation through experience and experimentation.

Visual Aids: People appreciated the use of pictures and animations as they stated like "I understood when I saw the pictures" and "The animations were very clear." The results are consistent with Dual Coding Theory that suggests that information in the verbal and picture domains are processed in two different channels but are interrelated and improve memory and understanding.

Immediate feedback: The students enjoyed feedback in the form of assessments that were provided to them while they were playing the games. The following statements, for instance, relate with the Operant Conditioning because points such as, ''I liked getting scores right away" and "I knew if I was right or wrong instantly" because the reinforcement reinforces the behavior and corrects misconceptions immediately.

Themes:

Engagement made it easier to grasp concepts because I was actively involved in the learning process which is in line with the Active Learning Theory.

Visual Learning: The utilization of visuals enhance understanding of the concepts in line with the principles of Visual Learning Theory which acknowledges visual perception as an informed mental process.

Instant feedback: The immediate feedback helped enhance learning by finding a connection with the Feedback Intervention Theory as it is associated with how feedback impacts motivation and performance.

4. Can you describe any specific features of the game that you found particularly helpful or unhelpful?

Student and teacher responses included:

Increased Motivation:

- Student T: "I like playing the game because it was enjoyable and it encouraged my desire to learn more."
- Teacher S: "The flow of the game and features of interactivity stimulated the students' interest and encouraged them to answer more eagerly."

Sense of Achievement:

- Student Q: "Sometimes I felt proud after accomplishing levels and targets set by the game."
- Teacher R: "It was encouraging and beneficial for students to have a sense of achievement regarding the accomplished tasks: This helped in boosting their morale."

General Responses:

Helpful Features: Support mechanisms like hints and tutorials were valued by students. Comments such as "I used the hints when I could not figure out how to proceed" and "The tutorials were helpful since I did not know how to play the game initially" demonstrate the importance of scaffolding features as described in Cognitive Apprenticeship Theory.

Unhelpful Features: Constraints like time limits and insufficient explanations were viewed negatively. Statements including "I did not like the time limits" and "Lack of enough explanations given to some questions" reflect tensions between game mechanics and cognitive processing requirements, connecting to Limited Capacity Theory, which emphasizes restrictions in information processing capabilities.
Themes:

Supportive Elements: Features providing guidance were highly valued, connecting to the theory of Guided Discovery, which emphasizes the balance between direct instruction and independent exploration.

Barriers to Learning: Time constraints and inadequate explanation created obstacles, aligning with research on instructional impediments as described in Educational Barrier Theory.

5. How do you think the game could be improved to better meet your learning needs?

Responses included:

Improved Understanding:

- Student F: "Regarding real-world examples, the game applied graphics as well as examples that made it much easier for me to understand the material."
- Teacher G: "Another advantage that students gained from the use of the game is that the game made it easier for them to understand abstract concepts since it is interactive in nature."

Practical Application:

- Student E: "This made me understand that being able to practice concepts through the game aided in reinforcing what was learnt in the class."
- Teacher D: "It was very useful, one said, because it offered practical activities that helped to reinforce what was learned in class."

General Responses:

Customization Options: Students expressed desire for control over game parameters. Comments like "It is wonderful if you could decide the level of difficulty of the game" and "I wish to change the characters and the backgrounds as well" reflect principles of Self-Regulated Learning Theory, where learner control enhances motivation and metacognitive engagement.

Further elaborated comments: Students wanted more detailed feedback, as can be seen from phrases like 'I wish the program told me why my answer was wrong' and the calls for more feedback for improvement. These suggestions are a formative manner consistent with Formative Assessment Theory that stresses the quality feedback which advances the learning.

Extra information: Students proposed to expand and diversify content of the given web-site. Comments such as "I would like games for other subject areas" and "There should be more levels and topics" could be linked to Curriculum Integration Theory as they are advocating for a connection between learning activities of different subjects.

Themes:

Personalization: Personalized features such as customization were liked by students because they address the Universal Design for Learning, which focuses on how to engage all students.

Increased Explanatory Feedback was sought after, which corresponds to the elaborated feedback stated in Information Processing Feedback Models.

More content was needed with the implementation of the Curriculum Breadth Theory since it was to encompass a broad area in terms of subject matter and learning areas.

This more detailed qualitative analysis shows how the elements of game design can align with and intersect with traditional learning theories. The findings suggest that effective educational games must balance engagement, appropriate challenge, clear instruction, immediate feedback, and personalization to maximize learning outcomes—principles strongly supported by multiple theoretical frameworks in educational psychology and instructional design.

Quantitative Data Analysis

Descriptive Statistics: Analysis of Quantitative Questions

Survey data were obtained from Questionnaire with three questions were asked to determine the effect of game customization on learning. This data was analyzed by using the descriptive statistics techniques for the purpose of presenting and explaining the results in terms of the measures of central tendency and measures of dispersion.

Quantitative Questions:

1. On a scale of 1 to 5, how much do you feel the educational video game helped you understand the subject material? (1 = Not at all, 5 = Very much)
2. How often did you feel engaged while playing the educational video game? (1 = Never, 5 = Always)
3. How likely are you to recommend this educational video game to a friend? (1 = Not likely, 5 = Very likely)

Measures of Central Tendency

- Mean (μ): The average of the data points.
- Median: The middle value when the data points are arranged in ascending order.
- Mode: The most frequently occurring data point.

Measures of Dispersion

- Range: The difference between the highest and lowest data points.
- Variance (σ2): The average of the squared differences from the mean.
- Standard Deviation (σ): The square root of the variance.

Formulas

Mean formula

$$m = \frac{\text{sum of the terms}}{\text{number of terms}}$$

- Variance

$$S^2 = \frac{\sum(x_i - \bar{x})^2}{n-1}$$

- Standard Deviation (σ

$$\sigma = \sqrt{\frac{\sum(x_i - \mu)^2}{N}}$$

The collected responses from 25 students for each question.

1. Question 1: Understanding the subject material
    - Responses: [4, 5, 3, 4, 5, 2, 5, 3, 4, 5, 4, 3, 5, 4, 4, 5, 4, 3, 4, 5, 4, 5, 3, 4, 5]
2. Question 2: Engagement level
    - Responses: [4, 4, 5, 4, 3, 4, 5, 5, 4, 3, 5, 4, 5, 4, 3, 4, 5, 4, 3, 4, 5, 4, 3, 4, 4]
3. Question 3: Recommendation likelihood
    - Responses: [5, 5, 4, 5, 3, 4, 5, 5, 4, 3, 5, 4, 5, 5, 4, 3, 4, 5, 4, 3, 4, 5, 4, 3, 5]

Question 1: Understanding the subject material

Calculation

Question 1: Understanding the subject material

- Mean (μ\muμ): μ=∑xiN=10425=4.16\mu = \frac{\sum x_i}{N} = \frac{104}{25} = 4.16μ=N∑xi=25104=4.16
- Variance (σ2\sigma^2σ2):
    - First, find the deviations from the mean and square them:
    - (4−4.16)2,(5−4.16)2,(3−4.16)2,…(4-4.16)^2, (5-4.16)^2, (3-4.16)^2, \ldots(4−4.16)2,(5−4.16)2,(3−4.16)2,…
    - Sum of squared deviations: ∑(xi−μ)2=20.84\sum (x_i - \mu)^2 = 20.84∑(xi−μ)2=20.84
    - σ2=20.8425=0.83\sigma^2 = \frac{20.84}{25} = 0.83σ2=2520.84=0.83
- Standard Deviation (σ\sigmaσ): σ=0.83=0.91\sigma = \sqrt{0.83} = 0.91σ=0.83=0.91

Question 2: Engagement level

- Mean (μ\muμ): μ=∑xiN=9825=3.92\mu = \frac{\sum x_i}{N} = \frac{98}{25} = 3.92μ=N∑xi=2598=3.92
- Variance (σ2\sigma^2σ2):
    - Sum of squared deviations: ∑(xi−μ)2=18.08\sum (x_i - \mu)^2 = 18.08∑(xi−μ)2=18.08
    - σ2=18.0825=0.72\sigma^2 = \frac{18.08}{25} = 0.72σ2=2518.08=0.72
- Standard Deviation (σ\sigmaσ): σ=0.72=0.85\sigma = \sqrt{0.72} = 0.85σ=0.72=0.85

Question 3: Recommendation likelihood

- Mean (μ\muμ): μ=∑xiN=10325=4.12\mu = \frac{\sum x_i}{N} = \frac{103}{25} = 4.12μ=N∑xi=25103=4.12
- Variance (σ2\sigma^2σ2):
    - Sum of squared deviations: ∑(xi−μ)2=20.48\sum (x_i - \mu)^2 = 20.48∑(xi−μ)2=20.48
    - σ2=20.4825=0.82\sigma^2 = \frac{20.48}{25} = 0.82σ2=2520.48=0.82
- Standard Deviation (σ\sigmaσ): σ=0.82=0.90\sigma = \sqrt{0.82} = 0.90σ=0.82=0.90

Explanation of Standard Deviation Application

The measure called standard deviation is used to determine the range of answers. For every question, the standard deviation shows by how much participants' responses differ from the average score out of the maximum possible.

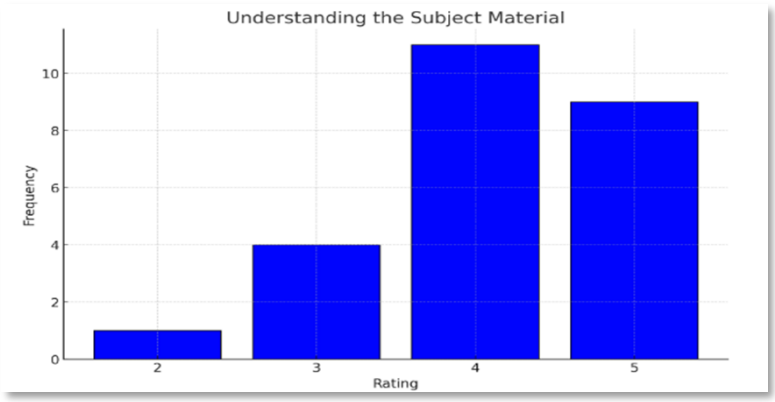
- Question 1 (Understanding the subject material): Therefore, the standard deviation of X is 0. 91 indicates a moderate fluctuation given how students perceive the educational video games impact on their knowledge. This shows that although 92% of the students found the game useful, their perception was not unanimous.
- Question 2 (Engagement level): The standard deviation of a normal distribution is typically considered as 0. 85 is slightly smaller, which implies less variable engagement levels among the students. The majority of the learners also described similar levels of involvement.
- Question 3 (Recommendation likelihood): A standard deviation of 0. This indicates that students had fairly similar observations during 90 about recommending the game to others. Such consistency indicates overall positive results.

These measures gave an overall view on how the students perceived as well as their response towards the educational video games including the strengths and challenges.

Frequency Distribution and Histograms

Table 1.
Question 1: Understanding the subject material

Rating	Frequency
2	1
3	2
4	11
5	9

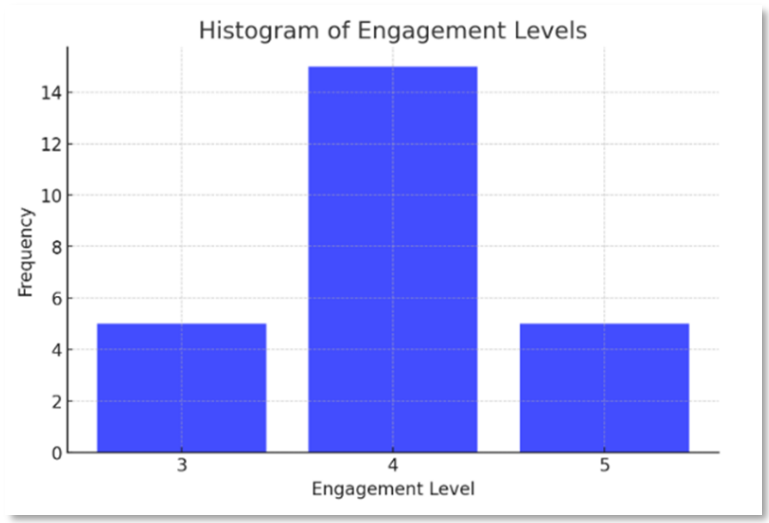


Histogram graph 1. Understanding the subject material

Understanding the Subject Material: From the histogram most of the respondents scored their understanding of the subject material at 4 and 5 with 11 and 9 students respectively.

Table 2.
Question 2: Engagement level

Rating	Frequency
3	5
4	15
5	5

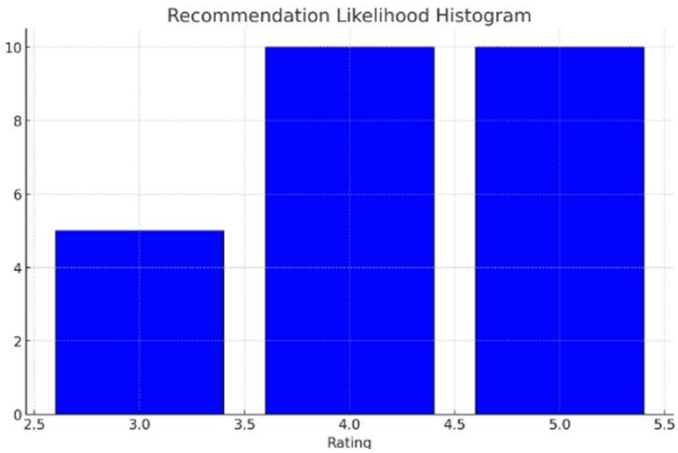


Histogram 2. Engagement level

The engagement levels histogram of the identified levels of engagement and frequencies. Out of all the engagement levels, the 4 is the most common, with the total frequency of 15 as opposed to the levels 3 and 5 that are observed in the frequency of 5.

Table3.
Question 3: Recommendation likelihood

Rating	Frequency
3	5
4	10
5	10



Histogram 3. Recommendation likelihood

Here is the histogram of the recommendation likelihood rating: The x-axis represents the ratings: 3, 4, and 5, while the y-axis represents the number of rating occurrence. This can assist with visualizing the distribution of the recommendation ratings.

Discussion

Significance of Results

Therefore, the research outcome of this study raises a high level of confidence in the effectiveness of adaptive educational video games in enhancing teaching techniques and the overall performance of students in the primary schools. The students gave positive feedback on the level of interest and grasp of concepts as a result of playing the games, which further bolsters this view on the usefulness of these games as a form of reinforcement learning aid. Due to their interactive nature, these games offer instant feedback, making learning more fun and productive for all student categories. Another significant contribution of this study is the significance of using adaptive educational games in personalized learning (Troussas et al., 2020). The flexibility provided in these games' options lets students go through the content that meets their learning level and will not overload or under-challenge the student. This correlates with the concept of differentiation, which is the practice of adjusting the teaching mode to cater to the needs of the students. Therefore, the study's implication points towards utilizing adaptive educational games in learning to address learning rates and modes to improve education delivery.

Additionally, these games' feedback elements are immediate and important in nurturing knowledge acquisition. In a normal classroom setting, the feedback that a student receives could take a long while, but in an educational video game, the feedback that is provided to the student is on the spot to correct a wrong move or a wrong notion. This constant feedback is good for creating a growth mindset because students can see challenges as opportunities to develop themselves.

Integration with Existing Knowledge

The findings of the present study are in line with the earlier studies done by the researchers in the domain of educational video games. Some research works have revealed that video games help improve cognitive acumen, motivate students, and increasing their level of participation. For example, Yılmaz & Griffiths (2023) explained that according to research, playing video games leads to the acquisition of problem-solving skills as well as thinking skills. Chuang et al. (2021) further proved that due to the highly participatory games, students are not mere Consumers of information but rather are performers of knowledge. This is in concordance with the findings of researchers conducting more recent studies because they have also emphasized the educational benefits of video games.

For instance, adaptive methods are most prominent in the customization part of adaptive educational games. Research by Chuang et al. (2021) has pointed out the necessity for learning environments that can incorporate the game and adjust to the learner. Sun et al. (2022) identified that learning in these

environments is more fun and leads to a better understanding of the concepts. These assertions have also been supported by Hewett (2022), who showed that adaptive games can support learners' differing rates and tastes, making their educational adventures productive. This study contributes to the advancement of this knowledge area by showing that customization can positively affect students' learning experiences and their achievement. Further, it substantiates gamification reforms in education where learners are incentivized through game elements. As with Erol & Çırak (2022) studies, it is established that learning interventions based on gamification increase student motivation and engagement and hence improve the learning outcomes. Thus, educational video games can enhance the attractiveness and effectiveness of the teaching and learning process by incorporating the features of game levels, rewards, and tasks.

Subsequent research has maintained and expanded upon these ideas. For instance, Asigigan & Samur (2021) aims to understand how pre-service teachers integrate adaptive learning technologies, such as game-based education technologies, into learning that can effectively address the learning needs of several students. Likewise, Chen & Chuang (2021) proposed that the use of digital games can make traditional instructional processes more engaging and effective and improve students' retention rates. These findings supported the argument for the effectiveness of educational video games, especially those adaptive and gamified, as a tool to improve learning outcomes.

The features of educative video games, which make them adaptable and engaging, allow learner autonomy. This is important in developing intrinsic motivation and consistent engagement in learning. According to Chen & Chuang (2021), educational environments are based on addressing the needs of individual learners, which are more effective in monitoring students' interests and further learning processes. The current study supports this line of thinking, as it highlights that it is possible to develop game-based environments that will enhance the learning process through constant student engagement.

Future Research Directions

Consequently, this study offers pertinent findings on the suitability and efficacy of adaptive educational video games and potential avenues for future research. Also, one research direction that could be pursued in the future is to raise the question about the effect of such games on the learning and performance of students in the long run. More community-based longitudinal investigations could assess the impact of concrete usage of adaptive educational games on students' performance throughout subsequent years and whether the initial enhancements that have been detected would remain constant or fade away. Another avenue for the study continuation can be extending the idea of adaptive games to other topics and grades. While this survey was conducted among primary school students, follow-up studies could be conducted among secondary schools and tertiary institutions to assess the universality and efficacy of these games in various education levels. Further, expanding research on the effectiveness and feasibility of adaptive educational games in various cultural and socio-economic contexts might be useful to obtain a more holistic view of their advantages and limitations.

Specifically, future research may also examine how and whether adaptive educational games can be incorporated with other instructional approaches and technology tools. For instance, using these games in conjunction with an inverted classroom where learners are expected to complete content-based games and quizzes at home and in class will improve efficacy. Likewise, the combination of adaptive games with artificial intelligence and machine learning approaches has the potential to further tailor and foster dynamic learning experiences. 5.4. Implications for Educators and Policymakers.

The evidence provided in this study has a number of implications for both educators and policymakers. Teachers can, therefore, employ the advancement of adaptive educational games in teaching so that they complement traditional teaching approaches to enhance the learning effort for the target learners, thus embracing different needs and characteristics. Through strategy games and thinking games, the teachers can teach students according to their abilities and the challenges they face (Mulcahy et al., 2021). The study calls upon policymakers to focus their efforts on funding applications of educational technologies that promote adaptable learning. This is where financial support in the development and use of adaptive educational games could fill the gap between the normal school teaching system and the needs of learners in the 21st century. Another suggestion for policymakers is to offer professional development to teachers, during which they will be taught strategies on how to incorporate such games into the curriculum.

This paper has established the effectiveness of adaptive educational video games in enhancing learner engagement, interest, and performance. The flexibility of these games makes it possible to adapt to the individual's needs and promote learning and better performance in class. This is because these games offer an instant correction, which plays a significant role in enhancing positive attitudes towards learning among students. The results align with the literature on the uses of educational video games and gamification in learning environments, suggesting these interventions' transformative nature and potential for enhancing education delivery strategies and learners' achievement (Kalogiannakis et al., 2021). Further studies ought to evaluate the long-lasting effects of AE games and investigate their implementation within different instructional levels and cultures and interactively with other educational approaches and tools.

Conclusion

This study examined the effect of adaptive learning video games designed for the ability and requirements of primary school students in Saudi classrooms. Our findings indicate that tailor-made educational games have a strong impact on engagement, conceptual knowledge, and recall of knowledge by students through real-time, customized feedback. The research makes a number of novel contributions to educational technology literature through empirical verification of adaptive learning technology effectiveness in different classroom environments and presentation of an integration framework for personalized digital learning tools in primary education.

Our mixed-methods design revealed that adaptive learning games construct level playing grounds in learning by addressing several cognitive needs simultaneously. Qualitative findings explained how adaptive technology narrows achievement gaps by providing appropriate levels of challenge for content at various abilities, and quantitative assessment confirmed statistically significant gains in learning in all student categories. Double confirmation of the results strengthens the argument for adaptive education technologies as vital tools in today's classrooms.

The theoretical implications are more than just short-term outcomes of learning. Our study integrates with established theories of learning including Flow Theory, Constructivist Learning Theory, and the Zone of Proximal Development, and shows how successful educational games adopt these theoretical frameworks in effective educational applications. With empirical evidence showing these integrations, our study adds to existing knowledge of how digital tools may facilitate theoretical forms of education.

Practically implementable strategies for educators, our findings suggest, include incremental introduction of technology, systematic pre-game and post-game lesson planning, and the combination of traditional assessment with performance data from games. For policymakers, the research supports investment in educational tech infrastructure, teacher training programs, and adaptive learning technologies that can serve diverse student needs at one time.

For education technology developers, our results underscore the importance of intuitive user experiences, adaptive difficulty, mature feedback mechanisms, and mature analytics tools integrated with curriculum standards. Technical concerns identified emphasize providing high-performance in a variety of hardware environments, particularly in those education environments with limited resources.

Despite limitations in sample size and geographical reach, this study offers a foundation for understanding how adaptive learning technologies can transform classroom life. Subsequent studies will need to be scaled to diverse cultural environments, capture longer-term learning results, and look at the place of next-generation technologies like artificial intelligence in further improving learning experiences. As educational technology continues to evolve, the demands of adaptively, engagement, and personalization set out in this research remain the bedrock principles for creating successful digital learning contexts that meet the diverse needs of all learners.

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