The Effectiveness and Student's Perception of an Adaptive Learning System

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A R T I C L E I N F O

A B S T R A C T

The study aims to examine the impact of an adaptive learning system on students' academic performance and their overall perception of using the system. This study employed a quantitative research design to gather data, ideas, and information. There are 55 participants in the study comprising 33 students for the treatment group (utilizing an adaptive learning system) and 22 students for the control group. The findings showed that the adaptive learning intervention increased student motivation leading to a more positive learning experience and no statistically significant difference exists between the perception of AL experience among academic status and specialization. Students who went through the adaptive learning intervention demonstrated improved academic performance overall. The study presents recommendations for implementing an adaptive learning system effectively, including comprehensive training for teachers and administrators, selecting appropriate platforms, training teachers, and monitoring student progress.

INTRODUCTION

The traditional approach has been widely used in mathematics education, it is important to note that contemporary pedagogical practices have evolved. There is increasing recognition of the importance of engaging students in active learning, promoting critical thinking, and fostering a deeper understanding of mathematical concepts. Many educators now incorporate a combination of traditional and modern teaching strategies to create a more balanced and effective learning experience for students. However, Qatar University, like many educational institutions, continuously strives for improvement and established a strategic plan for Educational Excellence Themes.

Qatar University, as a leading institution of higher education in Qatar, recognizes the need to explore innovative teaching and learning approaches to enhance student outcomes and meet the demands of a modern educational landscape. By identifying the strengths and limitations of the Adaptive Learning system and gaining insights into students' perceptions, the study aims to inform educational practitioners and policymakers about the potential of adaptive learning as a tool to enhance learning outcomes. Through this investigation, the study seeks to contribute to the existing body of knowledge on adaptive learning and its application in mathematics education, ultimately supporting evidence-based decision-making for improving teaching and learning practices in the department.

Due to advancements in technology in information and communication, many adaptive learning systems have become popular in education. These systems allow for personalized teaching to be delivered to large groups of students simultaneously. Shute & Zapata-Rivera, 2012; Modritscher, 2008). The number of e-learning systems and online degree programs has noticeably increased (Alenezi & Shahi, 2015). Despite the increase in using e-learning systems and their advantages such as access to different online resources, and self-directed learning, learning e-learning systems suffer from several problems. A lot of learners are easily leaving e-learning systems without satisfaction (Violante & Vezzetti, 2015; Fatahi, 2019; Asoodar et al., 2016; Salimon et al., 2021). Because this type of learning environment cannot interact with learners as well as traditional learning environments.

Adaptive learning has the ability to tailor the learning experience to suit the unique needs of each student by taking into account their strengths, weaknesses, and preferences. This personalized approach allows students to immerse themselves in the material at their own speed, enabling them to swiftly grasp concepts they have already mastered while dedicating more time to areas that they find difficult (Somyu¨rek, 2015). Many adaptive e-learning systems have been developed to consider human characteristics but most of these systems just consider emotions, mood, learning styles, motivations, or personality alone (Brusilovsky et al., 2002; Li et al., 2021; Fatahi, 2019; Pizon & Ytoc, 2022). There is a few research used a combination of some of the human characteristics together (Fatahi et al., 2016; Riad et al., 2009; Katsaris & Vidakis, 2021).

As a result, teachers may face challenges in effectively engaging and instructing their students, impacting overall learning outcomes. While adaptive

learning systems have shown potential in enhancing student learning outcomes and positive learning experiences, our school has yet to incorporate this technology into our educational practices. This gap presents an opportunity to explore and implement adaptive learning systems through the use of CK-12, which can address differing student proficiency levels, promote personalized instruction, and alleviate instructional challenges resulting from variations in students' readiness. By bridging this gap, our school can enhance the learning experience and support the academic success of our students.

Thus, the problem to be addressed in this study is to evaluate the effectiveness of the Adaptive Learning system in improving students' quiz performance in the Elementary Algebra course. Additionally, the study seeks to explore students' perceptions of their learning experiences with the Adaptive Learning system, investigating their contentment, and reasons for disengagement and frustration, to understand how it addresses their varying levels of proficiency and instructional challenges.

THEORETICAL REVIEW
Hypotheses

The following null hypotheses formulated and tested at 0.05 level of significance in this study are the following:

1. There is no significant effect of the adaptive learning skill level on students' quiz performance.
2. There is no significant difference in the performance of students who used Adaptive Learning and those who did not.

Figure 1 illustrates the conceptual framework of the study in an adaptive learning system which provides a theoretical foundation and structure for understanding the relationships between key variables and concepts. It outlines the key components, constructs, and factors that are central to the research investigation. In the context of the study on the effectiveness and students' perception of an adaptive learning system in the Foundation Program at Qatar University, the conceptual framework may include the Adaptive Learning System and Learning Outcomes. This study looked into the possibilities to link the student perception to the effectiveness of the adaptive learning system, the following depicts the conceptual framework that undergirds this study.

The central focus of the study is the adaptive learning system, which incorporates personalized instruction, adaptive practice, and tailored feedback based on individual students' needs, progress, and performance. The adaptive learning system serves as the intervention or treatment being investigated for its effectiveness and impact on student's learning outcomes and satisfaction The study of Beldagli and Adiguzel (2010) revealed that the adaptive leaning system as central focus incorporates personalized instruction, adaptive practice, and tailored feedback based on individual students' needs, progress, and performance. The adaptive learning system serves as the intervention or treatment being investigated for its effectiveness and impact on student's learning outcomes and satisfaction.

Khan and Ramachandran (2012) assess the effectiveness of the adaptive learning system by examining its impact on students' learning outcomes. This includes measures such as quiz performance, academic progress, and overall mastery of the learning objectives in Elementary Algebra. The study aims to determine whether the adaptive learning system leads to improved learning outcomes compared to traditional instructional methods. Adaptive e-learning employment in higher education has been slower to evolve, and challenges that led to the slow implementation still exist. The learning management system offers the same tools to all learners, although individual learners need different details based on learning styles and preferences (Beldagli & Adiguzel, 2010; Kolekar et al., 2017). The interactive e-learning environment requires evaluating the learner's desired learning style, before the course delivery, such as an online quiz, or during the course delivery, such as tracking student reactions (DeCapua & Marshall, 2015).

In e-learning environments, adaptation is constructed on a series of well-designed processes to fit the instructional materials. The adaptive e-learning framework attempts to match instructional content to the learners' needs and styles. According to Qazdar et al. (2015), adaptive e-learning (AEL) environments rely on constructing a model of each learner's needs, preferences, and styles. It is well-recognized that such adaptive behavior can increase learners' development and performance, thus enriching learning experience quality (Shi et al., 2013).
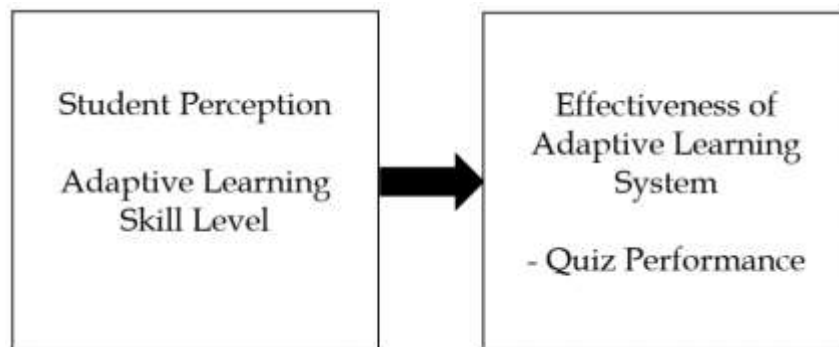

Figure 1. Conceptual Framework

METHODOLOGY

The study employed a quantitative research design which seeks to answer questions to the real facts relating to the existing condition. The participants were divided into two groups: the treatment group which utilized an adaptive learning system comprising 33 students, and the control group, comprising 22 students. The study adopts a purposive sampling technique in the selection of the respondents based on the following criteria; respondents should have utilized the content modules and Completed the quiz for the course.

Students enrolled in CK12 classes were urged to engage in and finish the designated modules. The instructor clarified the objectives, deadlines for adaptive practices, and methods for learning intervention. Each student was informed of the assigned modality (reading or adaptive practice) and could complete it at their own speed before the due date. The adaptive learning system

is comprised of two modules: Module 1 includes an interactive lesson and a module quiz, whereas Module 2 includes two interactive lessons and a module quiz.

The content module's questionnaire sets will undergo modifications and assessment by specialists in questionnaire construction. Recommendations from these experts will be thoughtfully reviewed and incorporated into the final version of the questionnaire. The author will then verify and confirm the validity of the standardized questionnaire's content after categorizing the questions. After collecting the data from all sources, the data were checked for further analysis, that is, fit the restriction of range in the data values, outliers, nonlinearity, and non-normality of data to determine the aptness of the generated model.

RESULTS AND DISCUSSIONS

Table 1. Student's Perception of the Content Module

Indicators	Weighted Mean	Verbal Interpretation
1. It was accessible and easy to use.	3.03	Agree
2. It helped me to understand the subject material better.	3.27	Strongly Agree
3. It motivated me to explore many questions or topics I may not have seen before.	3.27	Strongly Agree
4. It helped me assess my learning before, during, and after the topic discussion.	3.03	Agree
5. It helped me to build my confidence before taking the exam.	3.09	Agree
6. It motivated me to master the concept.	3.06	Agree
7. It helped me to improve my knowledge and increase my skills in math.	3.12	Agree
8. It helped me to improve my score performance in Math.	3.06	Agree
Average	**3.12**	**Agree**

Based on the results presented in Table 1, the students' perception of the content module was generally positive. Items 2 and 3 received the highest mean score of 3.27, indicating that students strongly agreed that they often understood the subject material better and were motivated to explore new questions or topics. This suggests instructional methods and resources were effective in clarifying complex concepts. On the other hand, items 1 and 4 received a slightly lower mean score of 3.03, still indicating positive agreement. This suggests that students perceived the content module as often accessible and easy to use, and it helped them assess their learning before, during, and after topic discussions. Overall, when considering all the enumerated items together, the mean score of 3.12 suggests that students rated their perception of the content module as agreeable. This indicates that the content module generally met students' expectations, providing them with a positive learning experience

The implications of these findings are significant for both educators and instructional designers. The high mean scores for items related to understanding the subject material and motivation to explore new topics indicate that the content module effectively facilitated students' learning and engagement. This highlights the importance of designing instructional materials that foster understanding, curiosity, and exploration (Yap, 2016). Additionally, Wandler and Imbriale (2017) emphasize the importance of creating content modules that are easy to navigate and provide effective learning assessments to support students' self-evaluation and monitoring of their progress. These results also demonstrate the overall success of the content module in meeting students' expectations and providing a positive learning experience. They underscore the importance of utilizing well-designed and engaging instructional materials to enhance student perception, motivation, and understanding (Kim, Richard, & Dattilo, 2002).

Table 2. Student's Perception of the Adaptive Learning Modalities

Modalities	Weighted Mean	Verbal Interpretation
1. Application/Introduction	3.27	Excellent
2. Adaptive Practice	3.27	Excellent
3. PLIX (Play Learn Interact Xplore)	3.15	Good
4. Videos	3.30	Excellent
5. Readings	3.30	Excellent
6. Real-World Problems	3.18	Good
7. Flexi – AI Tutor	3.36	Excellent

8.	Worksheet		3.55	Excellent
	Average		**3.30**	**Excellent**

Based on the results presented in Table 2, it can be observed that students' perception of the adaptive learning modalities is generally positive. The verbal interpretation of "Excellent" indicates that most modalities were highly rated by students, with an overall average weighted mean score of 3.30, suggesting a positive perception of the adaptive learning approach. The high ratings of most modalities by students contribute to the positive perception of the adaptive learning approach. The worksheet received the highest weighted mean score of 3.55, indicating that students perceived it as the best of the adaptive learning modalities and a valuable tool for improving their retention and comprehension of the subject matter. This favorable feedback highlights the potential advantages of incorporating worksheets into future adaptive learning experiences.

PLIX and Real-World Problems received slightly lower weighted mean scores of 3.15 and 3.18, respectively. Despite not being highly rated, these modalities were considered "Good" by students, as they enabled active participation in the learning process and practical application of knowledge. These modalities enhance students' understanding and retention of subject matter, contributing positively to their learning outcomes and reinforcing their knowledge. Despite receiving slightly lower scores, these modalities still contribute positively to students' learning outcomes and are seen as beneficial tools for reinforcing their knowledge.

Table 3. Test of Significant Relationship Between Adaptive Learning Skill Level and Quiz Performance

Adaptive Learning Skill Level		n	M	SD
Did not complete	0	5	34	18.17
Beginner	1	3	46.67	11.55
Exploring - Developing	2 - 3	18	47.67	14.76
Proficient - Mastery	4 - 5	17	78.35	14.6
		r-value = 0.236	**p-value = 0.031**	

The results of a study that examined the relationship between students' quiz performance and their adaptive learning ability levels are shown in Table 3. With a frequency of 17 and a mean score of 78.35 (SD = 14.6), the findings show that most participants attained proficient and mastery levels in adaptive learning. This shows that the test results were improved for pupils who showed stronger adaptive learning ability levels.

Conversely, there were 18 participants at the exploring and developing level of adaptive learning, with a lower mean score of 47.67 (SD = 14.67). Additionally, only five participants did not complete the adaptive learning module. These findings highlight the importance of progressing beyond the exploring and developing stage to attain proficiency and mastery in adaptive learning. It indicates that students who fully engage with and achieve higher levels of adaptive learning tend to perform better in quizzes compared to those who are at the initial stages or have not completed the module. The study also revealed a significant effect of adaptive learning skill levels on students' quiz performance, as indicated by the p-value of 0.031, which is lower than the predetermined level of significance (0.05). This means that the skill level in adaptive learning has a statistically significant impact on quiz performance. Furthermore, the positive correlation coefficient (r-value) of 0.236 suggests that as students' skill levels in adaptive learning improve, there is a corresponding increase in their quiz performance.

This aligns with existing literature that highlights the efficacy of adaptive learning systems. For instance, research by Johnson et al. (2016) demonstrated that adaptive learning platforms, which tailor educational experiences to individual students' needs, significantly enhance learning outcomes compared to traditional methods. Similarly, a study by Liu and Alexander (2017) found that adaptive learning tools improve student engagement and understanding by providing personalized feedback and adjusting content difficulty based on real-time performance. These findings are further supported by the work of Brennan et al. (2019), who reported that students using adaptive learning systems showed greater improvement in test scores and retention rates. Collectively, these studies corroborate the current study's conclusion that adaptive learning skill levels play a crucial role in enhancing academic performance, emphasizing the value of personalized educational technologies in modern pedagogy.

Table 4. Test of Significant Difference Between the Quiz Score of the Controlled Group and the Treatment Group

	Mean score	t-value	p-value	Decision
Control	55.71			
Treatment	60.06	-0.678	0.501	Accept H$_o$

Based on the results presented in Table 4, a comparison was made between the quiz scores of the controlled group (without adaptive learning) and the treatment group (with adaptive learning). The p-value of 0.501, which is larger than the predetermined level of significance (0.05), suggests that there is no statistically significant difference between the quiz scores of the two groups. Therefore, the null hypothesis is accepted, indicating that the use of adaptive learning did not result in a significantly higher quiz score compared to not using adaptive learning. However, it is important to note that although the results are not statistically significant, there is still a slight difference observed between the treatment group (M = 60.06) and the control group (M = 55.71). This implies that

the group that used adaptive learning tended to have slightly higher quiz scores compared to the group that did not use adaptive learning, although this difference was not significant enough to reject the null hypothesis.

This nuanced outcome aligns with existing literature. For instance, a study by Liu et al. (2019) found that while the immediate impact of adaptive learning on test scores may not always be significant, long-term use can lead to improved academic performance and better retention of knowledge. Similarly, the research by VanLehn (2011) suggests that the benefits of adaptive learning are often more pronounced over extended periods and with continuous use. Furthermore, Kulik and Fletcher (2016) found that adaptive learning technologies tend to show modest gains in performance metrics, which may not always reach statistical significance in short-term studies but can contribute to overall educational improvement. These findings highlight that while immediate, significant gains in quiz scores may not always be observed, the slight improvements noted could indicate the beginning of a positive trend that warrants further investigation and longer-term studies to fully understand the impact of adaptive learning systems.

CONCLUSIONS AND RECOMMENDATIONS

The students' perceptions of their adaptive learning experience were high. This indicates that the content module generally met students' expectations, providing them with a positive learning experience. The utilization of adaptive learning systems is an effective means of supporting learners, fostering engagement, and facilitating tailored learning experiences. The study shows a significant effect of adaptive learning skill levels on students' quiz performance, with improved skill levels indicating higher chances of improvement. These results suggest that adaptive learning can be an effective tool for improving student performance and should be considered in educational settings.

Based on the aforementioned findings and conclusions, the following recommendations are presented:

1. Adding an adaptive learning system or expanding the content coverage can greatly benefit both teachers and students. This can lead to increased engagement and better retention of information.
2. The findings of this study provide valuable insights into how such systems can be designed and optimized to maximize their effectiveness. System developers can use these insights to create more sophisticated algorithms that better understand student behavior and adapt accordingly

FURTHER STUDY

Future studies should expand on a larger population and prior academic performance that may impact students' perceptions of adaptive learning. Integrating adaptive learning with other instructional methods, such as project-based learning or flipped classrooms, can create a holistic, personalized approach to education. Further research in adaptive learning could lead to significant improvements in student outcomes and educational practices.

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