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Effect of Mobile Application Through Scenario Based Learning on Students' Achievement and Attitude Towards Nanotechnology in Chemistry

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Abstract

Nanotechnology is a rapidly developing field in the twenty-first century, and it has been included in Malaysian Form 4 and 5 chemistry curricula. There is still a lack of awareness and knowledge of nanotechnology among students, as well as a scarcity of literature on the development of nanotechnology teaching aids for teachers. The goal of this study was to create a mobile application (MyNanoRia) for secondary school students in Malaysia using scenario-based learning about nanotechnology. Another goal of this study is to determine the mobile application's usability score, as well as the effects of the mobile application on students' achievement and attitude toward chemistry. A total of 30 chemistry students took part in this study by answering the questionnaire designed for the study, which was chosen using the purposive sampling method via an online platform (Google Form). Statistical Packages for Social Sciences (SPSS) software was used to collect the data for further analysis. The mobile application was created with the ADDIE model and received an excellent usability score of 93.3%. In addition, the mobile application has a significant impact on students' achievement and attitude toward chemistry. This research demonstrated that the developed mobile application can be used as a teaching aid for the nanotechnology topic in chemistry classes.

Keywords: Nanotechnology; mobile application; scenario-based learning

Introduction

Future society depends heavily on the enormous, developing, and cutting-edge scientific field of nanotechnology. As a result, it is important to update and/or modify the curriculum in schools to ensure that instruction is tightly tied to practical application. Malaysia is one of the nations that have included nanotechnology in their curricula. The 2011 conversion of the Integrated Curriculum for Secondary School (KBSM) into the Standard Curriculum for Secondary School was a prudent move made by the Ministry of Education (MOE) (KSSM). One of the changes to the Chemistry curriculum is the addition of Chapter 13: Consumer and Industrial Chemistry to the Form 5 syllabus. A subtopic of the chapter is the use of nanotechnology in industry. However, there is little discussion of this subject and little exposure to the practical uses of nanotechnology in the chemical industry. Aside from that, there aren't enough resources for teachers to teach nanotechnology. The integration of technology in science education was also emphasised in 21st century learning. In fact, technology, such as mobile applications, is rapidly evolving, particularly following the COVID-19 pandemic outbreak. Many researchers have demonstrated the effectiveness of technology-based T&L on students (Jasmi et al., 2011).

There are also studies focusing on improving STEM education through the use of technology integration (Sahin & Yilmaz, 2020). The use of mobile applications is one example of rapidly evolving technology in STEM education. This is due to the rapid advancement of mobile technology and devices, which opens up a plethora of new opportunities for this technology to be used as a tool to improve educational approaches (Giannakopoulos et al., 2018). This claim is supported by a study conducted by Samad et al. (2021) on the use of mobile learning in T&L during the COVID-19 pandemic in Malaysia. The findings revealed that mobile learning had a positive impact on both teachers and students, as the use of this ICT element made education more enjoyable, improving students' attitudes toward learning. Aside from that, mobile learning allows teachers to have unlimited access to knowledge and teaching outside of the classroom. As a result, the focus of this research is on developing a mobile application about nanotechnology using the Scenario-Based Learning (SBL) approach and the Analysis, Design, Development, Implementation and Evaluation (ADDIE) model. Hence, the mobile application's usability and effectiveness in improving students' achievement and attitude toward chemistry were determined.

Methodology

Design and development research (DDR) was used in this work. Borg and Gall (1983) defined DDR in education as a method to create and validate an educational product. In particular, DDR possesses the procedures needed to create a mobile application with genuine features and content. Since creating mobile applications is the primary goal of this research, instructional design was employed to guide the development process. Table 1 provides information on the ADDIE model employed in this study.

Table 1: ADDIE model for mobile application development.

Phase	Explanation
Analyze	A needs analysis was conducted, asking teachers and students if there was a need to create mobile phone application for nanotechnology.
Design	By creating a flowchart, the mobile application's design was developed. Text, video, photos, and any other supplementary components made up the materials and media selection. The storyboard was updated to include all relevant information for each multimedia component, including texts, images, audio, and video.
Development	It involved repeating the review process and reworking the content programme, storyboard, flowchart programme, and screen design. To further elucidate the viability of the development, professional views and opinions were taken into consideration.
Implementation	The mobile application is regarded as being operationally sound and devoid of any technological problems. In this stage, Form 4 chemistry students from a secondary school in the Johor Bahru district and chemistry teachers were selected as respondent.
Evaluation	This procedure assesses the effectiveness and performance of the items. Evaluation has occurred throughout the whole development process, including throughout each phase, in between phases, and following implementation. The assessment could be summative or formative. This section of the study involved assessing the usability of the medium, student achievement, and attitude toward chemistry.

Our participants were Form 4 students (30 students), as the study's goal was to develop and identify the benefits of mobile phone application in increasing students' achievement and attitude toward chemistry. This is because the topic of nanotechnology is covered in their course curriculum. During the design phase, a process flow chart had been created to show the entire mobile application design. The flowchart for the mobile application is shown in Figure 1. Next, the storyboard is updated with the specifics for each multimedia piece, including texts, videos, and audios. The mobile application's features and design are centred on the SBL methodology. The mobile application has been finished by employing icons to express clear meanings in order to make sure it is user-friendly and simple to use. Home, for instance, is the icon for the homepage. The mobile application's interfaces are shown in Figure 2.

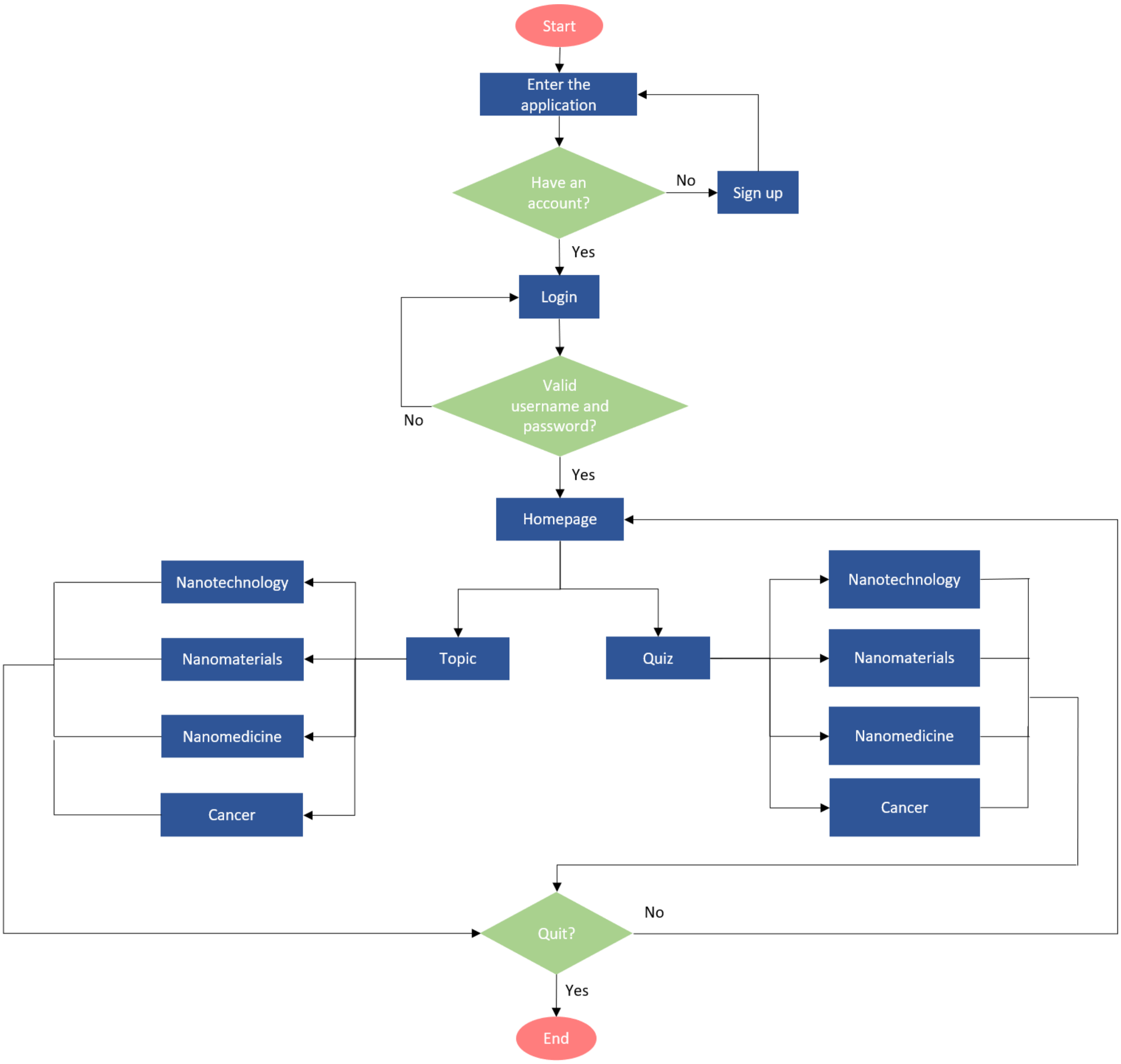

Figure 1 Mobile application flowchart.

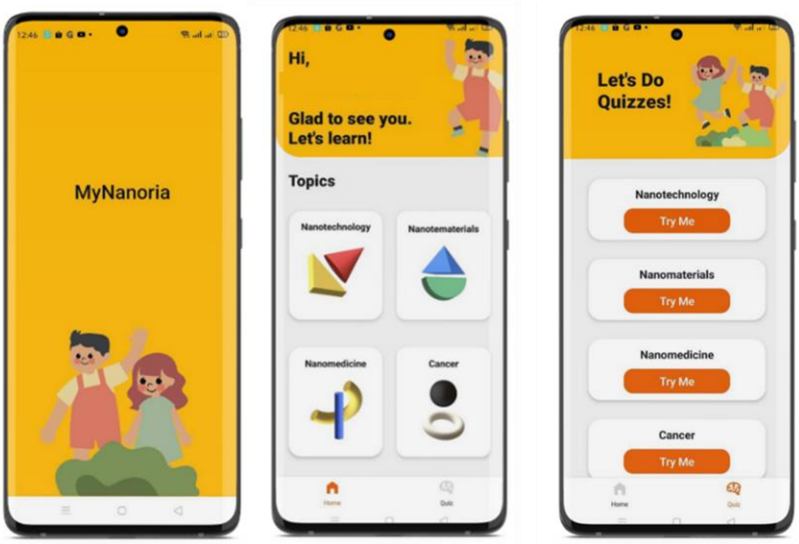

Figure 2 Interfaces of the mobile application.

The instrument used in this study was a questionnaire given to secondary school pupils in the Johor Bahru district. Basically, the questionnaire gathered data on the mobile application's media usability, student achievement, and chemistry attitude. In this quantitative study, the independent variable is the mobile application, while the dependent variables are the students' academic performance and attitude toward chemistry.

Finding the items required or qualities described in relation to media usability, student achievement, and attitude toward chemistry is vital in order to develop the questionnaire. First, the System Usability Scale (SUS), created by Brooke (1986), was used to create the media usability questionnaire, which was then adopted from Hariyanto et al. (2019). It has 15 items in the form of Likert scales. The three criteria used to evaluate media usability in this questionnaire are effectiveness, efficiency, and satisfaction. The reliability of this survey is 0.85. Table 2 gives the specifics for each media usability issue, and Figure 3's depiction of the SUS score category was used to determine the SUS score. Figure 3 shows that the lowest score within the allowed range of usability is 70%.

Table 2: Elements of SUS.

Elements	Number of Items
Effectiveness	1-9
Efficiency	10-13
Satisfaction	14-15

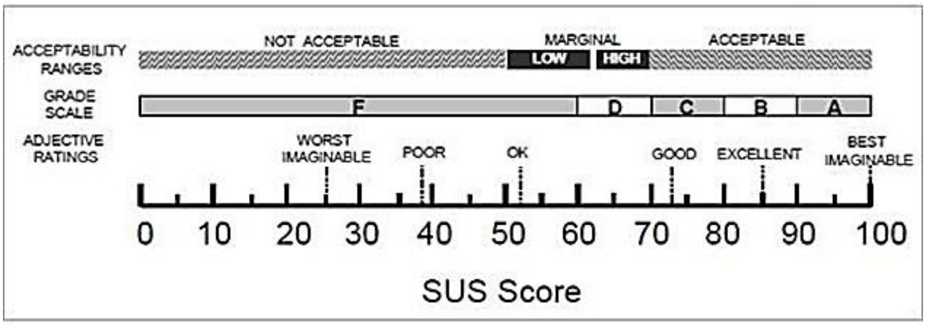

Figure 3 SUS Score Categorization (Hariyanto et al., 2019).

For the students' achievement, questionnaire was adapted from Nano-Knowledge Instrument (NanoKI) developed by Schonborn, Host and Palmerius (2015). However, this instrument was adjusted according to the context of this study. It contains 10 multiple choice questions related to the understanding of nanoscience and nanotechnology, with reliability of 0.91. This instrument consists of four themes, as shown in Table 3.

Table 3: Elements of Achievement Test.

Elements	Number of items
The nanoscale and the relative size of nano-objects.	3
Interactions between objects at the nanoscale.	3
Consequences of the surface area:volume relationship of objects at different scales.	3
Implications of nano-properties for developing nano-technologies.	1

The instrument for students' attitude towards chemistry was adopted from Attitude Toward Chemistry Lessons Scale (ATCLS) by Cheung (2009), which was modified from Test of Science-Related Attitudes (TOSRA) developed by Fraser (1978). It consists of 12 items with Likert-scale form. This questionnaire has four dimensions, which are liking for chemistry theory lessons, liking for chemistry laboratory work, beliefs about school chemistry and behavioural tendency to learn chemistry. This questionnaire has reliability of 0.91 and the details of each dimension are listed in Table 4.

Table 4: Dimensions of Attitude towards Chemistry Test.

Dimensions	Number of items
Liking for chemistry theory lesson.	1-3
Liking for chemistry laboratory work.	4-6
Evaluate beliefs about chemistry.	7-9
Behavioural tendencies to learn chemistry.	10-12

Results and discussion

A survey was conducted as part of the analysis phase to determine the demand for mobile nanotechnology applications. Both chemistry teachers and students participated in the survey in which 80 teachers and 43 pupils in total responded to the survey. According to the results in Figure 4, all students ready to using mobile applications to learn about nanotechnology, and 70% of them strongly concur. Additionally, 98 percent of the students and 63 percent of the strongly agreeing students felt that mobile applications are necessary to facilitate the learning process of nanotechnology. In summary, the majority of students are well prepared to utilise the mobile application and feel that it is necessary to do so in order to make learning about nanotechnology easier.

Then, the survey was conducted among teachers. According to the survey results, 84% of the teachers supported of using a mobile application to teach students about nanotechnology. In this instance, 40% of them strongly agreed. 94 percent of the teachers indicated their agreement with the necessity for mobile applications to aid in the learning process of nanotechnology. According to these findings, teachers are very much in favour of using mobile applications as a teaching tool for nanotechnology, although they are less ready than students. According to the current scenario, the school restricts or caps individual efforts and makes it challenging to study mobile technology pedagogically.

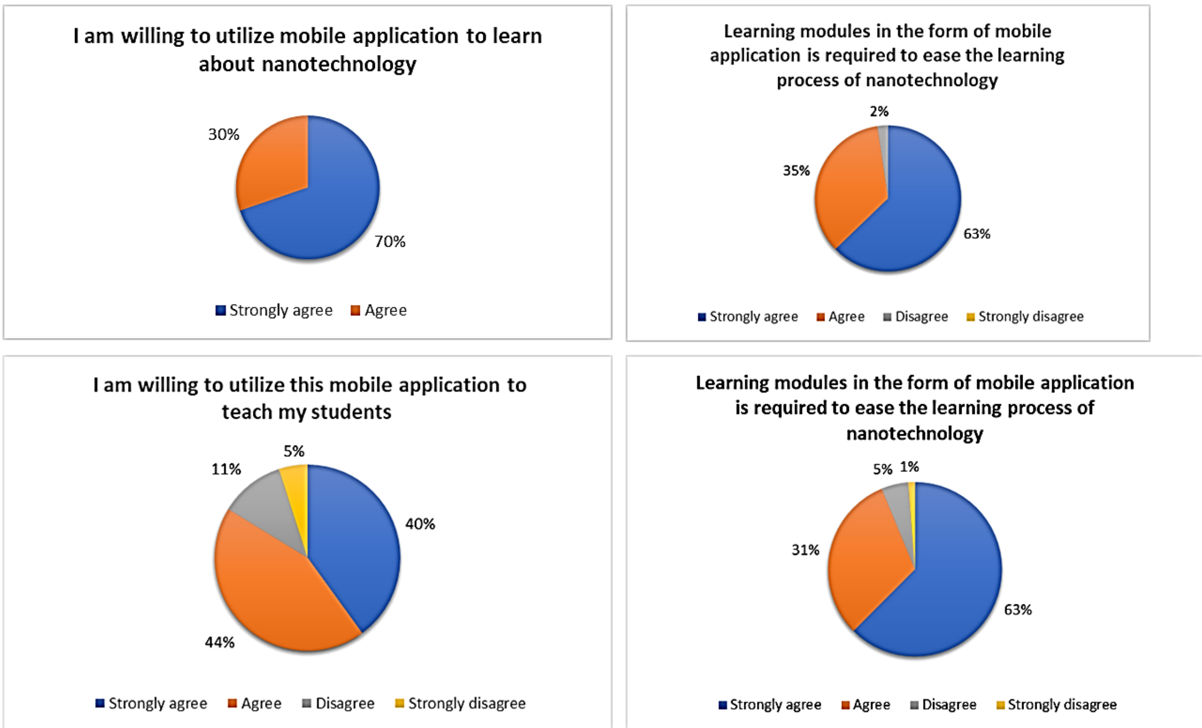

Figure 4 Results for need analysis for mobile application on nanotechnology.

The teachers' and students' ratings of the media usability are included in Table 5. This mobile app's media usability score, which was compiled from teachers, is 93.3 percent, which is regarded as good. The teachers gave the media usability scores of 92.2 percent effectiveness, 97.5 percent efficiency, and 90.0 percent satisfaction for each component. Overall, we can conclude that the teachers gave the mobile application a high usability score. Additionally, 89.3 percent of students gave the mobile application a positive overall rating, which is also great. In particular, the students gave media usability scores of 92.2 percent, 97.5 percent, and 90.0 percent, respectively, for effectiveness, efficiency, and satisfaction. According to these findings, mobile applications on nanotechnology are very user-friendly for both teachers and students. Additionally, the overall usability score for the mobile application is 89.9 percent, which is great.

Table 5: Media usability score.

Respondent	Aspects	Max score	Score	Average	Overall percent	Cumulative percent
Teacher	Effectiveness	180	166	0.922	93.3%	89.9%
	Efficiency	80	78	0.975		
	Satisfaction	40	36	0.900		
Student	Effectiveness	1080	943	0.873	89.3%	
	Efficiency	480	440	0.917		
	Satisfaction	240	224	0.93		

Using an accomplishment exam, the mobile application's effects on students' academic performance were evaluated. Prior to using the mobile application, the students took a pre-test; following that, a post-test was administered. To choose the best test for the data, a normality test was conducted first. To ensure that a parametric test may be performed, the data must be regularly distributed over all groups; otherwise, a non-parametric test should be used. Table 6 displays the outcome.

Table 6: Normality test for students' achievement.

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pre-Test Marks	.156	30	.062	.916	30	.021
Post-Test Marks	.186	30	.009	.913	30	.018

a. Lilliefors Significance Correction

Based on the result by Shapiro-Wilk test, the significance probability value for both pre-test and post-test is less than $\alpha = 0.05$ ($p = 0.021, 0.018, p < 0.05$), which shows that the data is not normally distributed. Since the data is not normally distributed, non-parametric test was chosen; Wilcoxon test. The results from the Wilcoxon test are shown in Table 7.

Table 7: Wilcoxon Test for the Achievement Test.

Test Statistics[a]	
	Post-Test Marks - Pre-Test Marks
Z	-4.755[b]
Asymp. Sig. (2-tailed)	.000

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

Based on the result for the Wilcoxon test, the significant (two tails) shows value of $p = 0.000$, thus $p < \alpha$) where $\alpha = 0.05$. Thus, the null hypothesis is rejected and we can conclude that there is significant difference of the pre-test and post-test marks of the students. In other words, there is significant effect of the mobile application on students' achievement.

Since chemistry is one of the fundamental pillars of science, student accomplishment is crucial in this subject. Majid and Rohaeti (2018) state that a variety of factors, such as conceptual comprehension and the learning environment, affect students' achievement. According to this study, the primary element influencing students' accomplishment was their first knowledge. According to a study by Komarudin et al. (2019), mobile applications can aid students in developing their conceptual knowledge in STEM subjects. Media experts evaluated the mobile applications, and the average percent score was 91.67 percent. The majority of students—76 percent—state that the mobile application is intriguing. In other words, the mobile application is amazing and good in terms of learning media and from the viewpoint of students. Other researchers have supported this claim further by stating that mobile applications can help students find answers to their queries, foster collaboration between friends and teachers, where they can readily share their knowledge, and maximise the results of their learning (Al-Emran et al., 2016). Additionally, this mobile software will be helpful for disabled pupils. This is due to the fact that using mobile applications, students will be able to catch up on their studies and learn independently or remotely from home (Lindner et al., 2019). Mobile applications have actually become a crucial component of education because they provide students and teachers with a variety of alternatives (Cornetta et al., 2019). This claim demonstrates why mobile apps are among the top learning resources available in the modern era.

Next, a test on students' attitudes toward chemistry is used to determine the impact of the mobile application on their attitudes. Prior to using the mobile application, the students took the pre-test; immediately following that, the post-test was administered. Wilcoxon test has been used to analyse the data because it is nonparametric. The Wilcoxon test result is displayed in Table 8.

Table 8: Wilcoxon Test for the Attitude towards Chemistry Test.

Test Statistics[a]	
	Post_Test - Pre_Test
Z	-4.724[b]
Asymp. Sig. (2-tailed)	.000

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

Based on the result in Table 8, the significant (two tails) shows value of $p = 0.000$, thus $p < \alpha$) where $\alpha = 0.05$. Thus, the null hypothesis is rejected, and we can conclude that there is significant difference of the pre-test and post-test for the students' attitude towards chemistry. In other words, there is significant effect of the mobile application on students' attitude towards chemistry.

The subject's curriculum and substance have an impact on students' attitudes (Yunus & Ali, 2018). Due to the challenging curriculum and syllabus, the majority of students displayed a negative attitude toward chemistry, and their attitudes are mostly shaped by their sentiments, beliefs, and skills (Ratamun & Osman, 2018). Chua and Karpudewan's (2015) assertion that chemistry students have a poor attitude about the topic and that the numbers are rising each year supports this claim. According to van Griethuijsen et al. (2015), students' interest in chemistry will increase when they see that there are more fascinating and rewarding experiences outside of school. ICT was recommended as the best option by Ratamun and Osman (2018) in this situation to improve students' attitudes toward chemistry.

Mobile applications were recommended by Naik (2017) as the ideal way to improve students' attitudes toward scientific learning. According to Hamari et al. (2016), students' attitudes toward learning chemistry are highly correlated with how much time they spend on mobile applications. This statement is consistent with a study by Ewais et al. (2021), which found that exposure to mobile applications improved students' attitudes toward chemistry. Apart from that, the pupils are quite appreciative of using the mobile app. Additionally, Hill and Simha (2016) created a mobile application that improved students' academic performance and attitudes toward their studying. The students also provide favourable comments and assessments of the mobile application, which are corroborated by the findings of earlier research (Demir & Akpinar, 2018). These quotes demonstrate that mobile applications can significantly improve students' learning of chemistry outside the regular classroom.

In contrast, according to Zaranis et al. (2017), teachers exhibit a positive attitude toward information and communication technologies (ICT) by being creative with how they employ ICT, like mobile applications, during teaching sessions. This demonstrates how utilising ICT as a teaching tool in the classroom may spark and improve instructors' creativity. This may be due to the fact that active students who use technology gadgets like mobile applications are more engaged and productive (Chen et al., 2017). Therefore, it is possible that teachers will be more inventive in facilitating meaningful learning when the pupils are engaged and more productive.

Conclusion

Using the ADDIE concept, a successful mobile application has been created for this study. According to the research's findings, the mobile application's usability score is 89.9 percent, which is above and beyond acceptable and is regarded as an excellent medium. The pupils also displayed impressively positive results in their academic performance. As previously said, this is encouraging for the creation and application of mobile applications in the field of chemistry teaching. As a result, it can be concluded that the second research question is addressed by the findings about the mobile application's noteworthy impact on students' academic performance. The mobile application's effectiveness in changing students' attitudes toward chemistry is the study's other significant finding. This leads to the conclusion that mobile applications focused on nanotechnology can significantly raise student accomplishment levels, not just in secondary but also in primary and early childhood education.

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