International Education Journal, Volume No.16, 2025

Innovative Tools for Secondary Science: Exploring ePathshala's AR Learning Experience

Vinod Kumar Kanvaria, Gunjan

A recent study investigated how augmented reality (AR) technology affects students' perceptions of scientific education and learning objectives. Eighth-grade pupils were split into control and experimental groups for a study that was carried out in the Pilibhit, District of Uttar Pradesh. The latter combined traditional education with the ePathshala AR Mobile App. The favorable effects of augmented reality on students' attitudes toward science and analytical learning outcomes were demonstrated by the results of pretest and posttest evaluations. The study, which included 74 participants overall, recommends using augmented reality (AR) technology—more particularly, the ePathshala AR App—to help students understand scientific subjects. The NCERT app, which is funded by the Indian government's Ministry of Human Resource Development, is in line with Digital India's objectives of using technology to promote skill development and educational empowerment. By encouraging active student exploration and interaction, this program makes scientific education more dynamic and successful.

Key words: *ePathshala AR Application; Augmented Reality;Science learning; Science Achievement Test; Self-made achievement test; secondary school.*

DOI : 10.5281/zenodo.17329196

Introduction

The accomplishments and advancements in science education in schools are noteworthy and demand greater attention (Wellcome, 2015).In recent years, augmented reality (AR) has become a popular use of new technology in educational settings. Augmented reality (AR) is a technology that creates a world in which real and virtual things can interact in real time, blend virtual and real-world objects, and have virtual objects that seem to complement real-world objects(Azuma, 1997). AR is “augmenting natural feedback to the operator with simulated cues”(Milgram, 1994).

Education academics are starting to identify the new opportunities AR technology offers for teaching and learning (Wu et al., 2013).Specifically, because AR grabs students' attention, it makes it easier for them to adjust to a lesson (Winkler et al., 2002). Particularly when it comes to teaching invisible things and events, illustrating risky circumstances, embodying abstract concepts, and presenting complex information, augmented reality (AR) is more effective (Walczak et al., 2006).Although the evidence suggests that AR can be used in many educational domains, science is one of the main fields where AR applications are used in the classroom since students find science lectures' abstract notions difficult to understand (Palmer, 1999).

One of the most important aspects of AR pedagogy is that it provides a flexible, student-focused environment for learning possibilities. Instead of taking place in traditional settings like labs, amphitheaters, or classrooms, learning now happens wherever the students are. Learning opportunities are everywhere and can be passed to everyone. They can be found, for instance, at the office, at home, or on public transportation. Students can become co-creators and critics as augmented reality (AR) advances, leaving behind a record of their learning about the particular artifact or location they have visited (Billinghurst & Dünser,2012).

The following five approaches show how using AR is consistent with good teaching practices: 1)Learning engagement (Di Serio, Ibáñez, & Kloos, 2013; Dunleavy, Dede, & Mitchell, 2009); 2)Immersion and presence in content (Lee, 2012); 3) Learning situate to a location or context (Dunleavy, Dede, & Mitchell, 2009; Kamarainen et al., 2013); 4)Content authentication (Wu, Wen-Yu, Chang, & Liang, 2013); and 5) community building (e.g., collaboration, competition) (Dunleavy, Dede, & Mitchell, 2009).

AR gives us new methods to engage with the real world and transforms how individuals use their mobile devices for learning (Joan, 2015; Grubert & Grasset, 2013; Haag, 2013). By utilizing AR-based interactive multimedia, learning materials can be made more engaging and succinct without sacrificing the essential content, as pupils appear to be seeing actual items. In the current study, 8th-grade students were taught AR-based science curriculum using NCERT's ePathshala AR mobile application. The goal of the current study is to use the ePathshala AR (Augmented Reality) mobile application to teach science in a way that is experiential, student-centered, and interactive.

The goal of the e-Pathshala AR (Augmented Reality) App, an NCERT project funded by the MHRD-Government of India, is to improve interaction between children and adults as well as between students and educators. Students will be able to acquire concepts through direct experimentation rather than just reading and memorization, thanks to their heightened interest as a result of the enhanced interaction. This is a revolutionary attempt to turn most students in the student body from being passive listeners to being active learners. The goal of Digital India, as outlined by the Prime Minister, is to use technology to empower a variety of industries while meeting the three key needs of speed, scale, and talent (https://ciet.ncert.gov.in/ar-vr).

Significance of research

- This study highlights the potential of augmented reality (AR) technology to transform conventional teaching approaches by providing teachers with cutting-edge resources to improve student comprehension and engagement.
- Using augmented reality (AR) technology in science classes might enhance students' academic performance, especially in critical thinking abilities, and help them understand scientific ideas more deeply.
- This research helps in understanding how technology may foster interest and drive, turning passive learners into active participants in their education by immersing students in interactive augmented reality experiences.
- The knowledge gathered from this research can help curriculum designers and educational officials make informed decisions on the effectiveness of integrating augmented reality (AR) technology into formal education settings, which could have an impact on upcoming reforms and investments in education.

Objectives of research

- To study how AR-based science content affects 8th-class students' learning outcomes.
- To investigate how AR-based science content affects the various cognitive domains of 8th-class students' learning achievement.

Hypotheses of research

H1-Students in the control and experimental groups are not significantly different in their mean scores on the science learning achievement test.

H2-The mean scores of students in the control and experimental groups in the various cognitive domains of science learning achievement are not significantly different from one another.

Literature review

S. No.	Authors	Objectives	Measures used	Findings
1.	Valarmathie Gopalan, Abdul Nasir Zulkifli, Nur Fadziana Faisal Mohamed, Asmidah Alwi, Ruzinoor Che Mat, Juliana Aida Abu Bakar, Aeni Zuhana Saidin (2015)	This study presented an improved science textbook that uses the Augmented Reality (e-STAR) application to help students understand science. Students' motivation to be more engaged in science is the goal of the e-STAR.	Quantitative data was gathered through the use of questionnaires to assess the following aspects: motivation, usability, enjoyment, and fun.	The outcomes showed that every dimension was agreed upon by the users. The results demonstrated that the e-STAR application may be one of the possible remedies for the issue.
2.	A. Syawaludin , Gunarhadi , P. Rintayati (2019)	The research aimed to enhance students' abstract thinking skills in science education by utilizing interactive multimedia that leverages augmented reality (AR) for fifth-grade pupils.	Data collection techniques used tests and observations, the credibility of the research data was examined based on technical triangulation and source triangulation while the collected data were analyzed descriptively.	According to the study's findings, fifth-grade elementary school pupils' ability to reason abstractly could be improved by using interactive multimedia based on augmented reality.
3.	**Dilara Sahin &**Rabia Meryem Yilmaz (2020)	The purpose of this study was to find out how middle school students' attitudes regarding AR apps and their level of accomplishment in the course are affected by learning	This study used a quasi-experimental design in which 100 middle school pupils in their seventh grade were	It was discovered that compared to students in the control group, those in the experimental group had better

		materials created using AR technology.	randomly assigned to either the experimental or control group in intact classrooms at two different schools.	achievement levels and more positive attitudes toward the course. Furthermore, the outcomes demonstrated that the students expressed satisfaction and a desire to keep utilizing augmented reality applications in the future.
4.	Miriam Gamboa-Ramos Ricardo Gómez-Noa , Orlando Iparraguirre-Villanueva Michael Cabanillas-Carbonell , José Luis Herrera Salazar (2021)	This article demonstrated the creation and impact of an augmented reality smart phone application that helps students in the sixth grade of primary school and first year of secondary school understand science and technology.	The research design is pre-experimental because pre- and post-test tests were conducted, and the Mobile D approach is employed throughout the application development process.	Final results showed that students' interest levels have increased to 100%, their understanding has improved by 50%, and their satisfaction levels have remained between 40% and 60%, suggesting that the application is helping them learn more.
5.	Turki Alqarni (2021)	This study looked at how using augmented reality (AR) affected the learning results and attitudes of sixth-grade Jordanian students toward science.	The pre- and post-tests are conducted before a quantitative quasi-experimental investigation. The two scales that were employed in this study were valid and reliable.	The findings demonstrated that augmented reality technology significantly improves student learning outcomes. Furthermore, the outcomes corroborated the notion that augmented reality technology can improve the positive attitudes of children with learning difficulties.
6.	Chiew Lin Yap, Jaya Kumar Karunagharan, Jason Chia Keh Leong, Iman Yi Liao, Hock Siang Lee (2023)	To help students grasp the idea of unimolecular nucleophilic substitution (S N 1) and bimolecular nucleophilic substitution (S N 2) reaction processes, a prototype augmented reality smartphone app called "Immersive Nucleophilic Substitution" (INS) has been developed. The purpose of this study is to investigate how university Foundation in Science students see and use the INS app.	The perceptions of the AR in terms of performance, effort, social impact, and motivation, as well as the user experience in terms of presence, usability, and flow, were measured using an online questionnaire that employed a 7-point Likert scale. In order to learn more about the participant's	Although they felt the app was less entertaining and inspiring, students said it was more useful for improving their learning productivity. They said the software had an excellent interface, responded effectively to the actions of the children and offered sufficient realism. But in some ways, it is needlessly

			experience using the INS app, open-ended questions were incorporated.	complicated, tedious, and uninteresting. The INS app was generally well-received by students, as seen by the overall good rating, and it was viable to move forward with the learning outcome evaluation.

The literature assessment concludes that there is great potential for augmenting science teaching with augmented reality technologies. Research has indicated that there are beneficial effects on student attitudes about the subject as well as learning outcomes, especially at the analytical level. For scientific students, integrating augmented reality apps such as ePathshala can create a more stimulating and productive learning environment.

Methodology

Research design

In order to determine the impact of AR-based science content utilizing the AR ePathshala app on students' science learning achievement, the current study used an experimental technique with two groups of randomly matched subjects and a pretest–posttest design. A pretest was given to the experimental and control groups to determine the degree of homogeneity within the groups.

The AR ePathshala smartphone app was used to administer AR-based science information to the experimental group, while a conventional book-based teaching approach was used for the control group. To ascertain whether the treatment was effective, a post-test was used. The study adhered to experimental design patterns (Table 1).

Table 1: Experimental design pattern

Randomly assigned groups	Independent variable	Pretest–Posttest design
Experimental	Teaching AR-based science content via AR ePathshala mobile app	Self-made Achievement test of Science
Control	Teaching through traditional method	

Sample selection

The sample for this study consisted of 74 students from the Ben-Hur Public School in the Pilibhit area of Uttar Pradesh which is connected with the CBSE board. Details of the sample are given in Table 2. Permissions from the school administration were obtained beforehand toexperiment.

Table 2: Sample of the study

Name of the school	Students in Experimental group		Students in control group	
	Boys	Girls	Boys	Girls

Ben-Hur Public School	22	15	20	17
	37		37	
Total	74			

Tools and tool development

A self-made Science Achievement Test has been utilized to gauge students' learning progress. According to the opinions of subject matter experts, the investigator has developed the test.Following item analysis and preliminary tryouts, there were forty things on the final test.

The test's split-half reliability was calculated, and the result showed that the test's reliability was 0.8, which is considered fairly good. While preparing the test, the test's face and content validity were guaranteed. Conciseness, difficulty level, and content are all given adequate weight(Table 3).

Table 3: Weightage given to different areas of the Self-made Achievement Test

S. N.	Weightage Area		Total no. of items	Percentage
1.	Content	Biology (Cell: the fundamental unit of Life)	15	37.5
		Chemistry (Acid and Base)	12	30.0
		Physics (Force)	13	32.5
2.	Cognitive area	Knowledge	10	25.0
		Understanding	14	35.0
		Application	16	40.0
3.	Difficulty level	Easy	18	45.0
		Average	15	37.5
		Difficult	07	17.5

Data collection method

Students were first divided into two groups at random: the experimental and control groups. Both the experimental and control groups included 37 students. The investigator has guided subject teachers and given them the required direction so they may teach the various AR-based science ideas included in the study using the AR ePathshala mobile application. The instructor used a projector screen to show the experimental group how to use applications through demonstrations. This application inspired students to practice the science material. Under the supervision of the same teacher, the control group used the traditional book-based style of instruction.

The data for additional research was gathered both before and after the trial by administering the self-made Test of Achievement.

Data analysis technique

The estimated t-value, mean, and standard deviation were used to assess the significance of the proposed hypotheses. The study employed a t-test to examine the difference between the pre- and post-test mean scores of the experimental and control group. For the analysis of the t-test, the significance level was set at the recommended $p<0.05$ at 72 degree of freedom.

Results

Presentation of findings

Table 4 and 5 displays the kind of analysis that was applied to show the significance of the study’s hypotheses.

Table 4: t-test conducted for Science Achievement Test

S. N.	Group compared	N	Mean	Mean difference	SD	df	t-test value
1.	Pre- test control Pre–test experimental	37 37	18.54 18.83	0.29	4.00 3.43	72	0.732794125
2.	Post-test control Post-test experimental	37 37	23.10 30.62	7.52	4.05 3.78	72	0.000 (5.35934E-12)
3.	Pre-test control Post-test control	37 37	18.54 23.10	4.56	4.00 4.05	72	0.000 (1.31468E-07)
4.	Pre-test experimental Post-test experimental	37 37	18.83 30.62	11.79	3.43 3.78	72	0.000 (1.25236E-17)

significant values at 0.05 level of significance

Table 5: t-test value for different cognitive areas of Learning

Cognitive area of learning	Group	N	Mean	SD	t-test value
Knowledge	Control	37	3.48	1.36	0.000 (1.36367E-15)
	Experiment	37	6.83	1.46	
Understanding	Control	37	7.78	2.34	0.000 (8.40259E-09)
	Experiment	37	11.24	2.21	
Application	Control	37	7.91	2.40	0.000 (1.54264E-10)
	Experiment	37	12.02	2.32	

Data analysis and interpretation

Table 4 depicted that calculated t-values are less than the critical value (1.99, df=72) at the 0.05 significance level which means the null hypothesis (H1) has been rejected. Therefore, students in the control and experimental groups are significantly different in their mean scores on the science learning achievement test.The experimental group exposed to AR-based (ePathshala app) science content learning performed better than the control group which was taught by conventional methods only.

The effects of AR-based science content on several cognitive learning domains are analyzed in Table 5. t-test values for cognitive areas of learning (knowledge, understanding, and application) are less than the critical value at the 0.05

significance level at 72 degree of freedom which rejects the H2. Therefore, we can conclude that the mean scores of students in the control and experimental groups in the various cognitive domains of science learning achievement are significantly different from one another. Knowledge, understanding, and application domains of the cognitive learning domain were positively impacted by learning using AR-based science information.

Support for the research hypotheses

H1-Students in the control and experimental groups are not significantly different in their mean scores on the science learning achievement test.

In order to evaluate the significance of the hypothesis, calculations were made for the mean, standard deviation, t-value, and significance (Table 4). It is evident from the table that the computed t-values at 72 degrees of freedom are less than the tabular value of 1.99. This rejected the null hypothesis, which claimed that there was no difference in the experimental group's and control group's learning outcomes. The experimental group, which was taught science content using the ePathshala app through augmented reality, outperformed the control group, which was taught using just traditional means.

H2-The mean scores of students in the control and experimental groups in the various cognitive domains of science learning achievement are not significantly different from one another.

The analyses of how AR-based science content affects several cognitive learning domains are shown in Table 5. Comparing the mean scores for the control and experimental groups revealed that the t values for the knowledge ($t(72) = 1.36367E\text{-}15$, $p<0.05$), understanding ($t(72) = 8.40259E\text{-}09$ $p<0.05$), and application ($t(72) = 1.54264E\text{-}10$, $p<0.05$), which are less than the critical value at the 0.05 significance level at 72 degree of freedom which rejects the H2 that means,the knowledge, understanding, and application domains of the cognitive domain of learning were positively impacted by learning using AR-based science content.

Discussion

This study aimed to find out if secondary school students' learning achievement in science was impacted by AR-based science content. Students in the experimental group were shown ePathshala as a tool for understanding this science material through AR. According to data analysis, students' scores in scientific success in the knowledge, understanding, and application domains of the cognitive domain of learning were positively impacted by AR-based science content.

The study provided the experimental group's students with an engaging, interactive three-dimensional model of several subjects, piquing their curiosity and making them eager to learn. This study backs up the idea of teaching students diverse subjects with the AR ePathshala app.

Implications of the research

The investigation of ePathshala's augmented reality science learning application has important educational implications for improving science students' engagement, understanding, and retention. Teachers may give students immersive, engaging experiences that close the gap between abstract ideas and practical applications by incorporating augmented reality technology into the classroom. This method may be able to accommodate a variety of learning preferences, encourage active learning, and provide a deeper comprehension of intricate scientific concepts. Furthermore, the availability of augmented reality technology on mobile devices allows for customized and adaptable learning experiences both inside and outside of the classroom, which promotes lifelong learning and information acquisition.The study's overall conclusions highlight the revolutionary potential of augmented reality (AR) in secondary science teaching and present teachers with chances to use technology to design dynamic, productive learningenvironment.The results of this study may also guide curriculum development and educational policy as technology advances, helping teachers to successfully integrate augmented reality tools into their lesson plans.

Limitations of research

The availability and usability of augmented reality technology will determine the intervention's effectiveness. The timeframe of the study may limit the capturing of long-term effects on secondary scientific learning. The results might not be generalizable since they rely on a particular application and setting.

Conclusion

In conclusion, the ePathshala app's use of augmented reality presents a viable option for improving secondary scientific education. The experimental group, which was taught science content using the ePathshala app through augmented reality, outperformed the control group, which was taught using just traditional methods. Also, learning with AR-based science information had a positive effect on the cognitive learning domain's knowledge, understanding, and application domains.

Recommendations for future research

The idea of augmented reality and its implementation in the classroom is still relatively new, therefore it's important to spread awareness of these kinds of smartphone apps that pre-service and in-service instructors can utilize to help the Alpha Generation learn abstract concepts.

Future research is advised to examine how augmented reality can be included into hybrid learning models that combine face-to-face and virtual learning to optimize the advantages of each. Also, promote continuous development in augmented reality technology, with an emphasis on customizing innovations to the unique demands and specifications of secondary science education.

References

Alqarni, T. (2021). COMPARISON OF AUGMENTED REALITY AND CONVENTIONAL TEACHING ON SPECIAL NEEDS STUDENTS'ATTITUDES TOWARDS SCIENCE AND THEIR LEARNING OUTCOMES. *Journal of Baltic Science Education*, *20*(4), 558-572.

Arici, F., Yilmaz, R. M., & Yilmaz, M. (2021). Affordances of augmented reality technology for science education: Views of secondary school students and science teachers. *Human Behavior and Emerging Technologies*, *3*(5), 1153-1171.

Azuma, R. T. (1997). A survey of augmented reality. *Presence: teleoperators & virtual environments*, *6*(4), 355-385.

Billinghurst, M., & Duenser, A. (2012). Augmented reality in the classroom. *Computer*, *45*(7), 56-63.

Chang, R. C., Chung, L. Y., & Huang, Y. M. (2016). Developing an interactive augmented reality system as a complement to plant education and comparing its effectiveness with video learning. *Interactive Learning Environments*, *24*(6), 1245-1264.

Di Serio, Á., Ibáñez, M. B., & Kloos, C. D. (2013). Impact of an augmented reality system on students' motivation for a visual art course. *Computers & Education*, *68*, 586-596.

Dunleavy, M., Dede, C., & Mitchell, R. (2009). Affordances and limitations of immersive participatory augmented reality simulations for teaching and learning. *Journal of science Education and Technology*, *18*, 7-22.

Grubert, J., & Grasset, R. (2013). *Augmented reality for Android application development*. Packt Publishing Ltd.

Gamboa-Ramos, M., Gómez-Noa, R., Iparraguirre-Villanueva, O., Cabanillas-Carbonell, M., & Herrera Salazar, J. L. (2021). Mobile application with augmented reality to improve learning in science and technology.

Gopalan, V., Zulkifli, A. N., Faisal Mohamed, N. F., Alwi, A., Che Mat, R., Abu Bakar, J. A., & Saidin, A. Z. (2015). Evaluation of e-star: An enhanced science textbook using augmented reality among lower secondary school student. *Jurnal Teknologi*, *77*(29), 55-61.

Haag, J., & DevLearn, A. (2013). Using Augmented Reality for Contextual Mobile Learning (Nov 13).

Joan, D. R. (2015). Enhancing education through mobile augmented reality. *Journal of Educational Technology*, *11*(4), 8-14.

Kamarainen, A. M., Metcalf, S., Grotzer, T., Browne, A., Mazzuca, D., Tutwiler, M. S., & Dede, C. (2013). EcoMOBILE: Integrating augmented reality and probeware with environmental education field trips. *Computers & Education*, *68*, 545-556.

Lee, K. (2012). Augmented reality in education and training. *TechTrends*, *56*, 13-21.

Milgram, P., Takemura, H., Utsumi, A., & Kishino, F. (1995, December). Augmented reality: A class of displays on the reality-virtuality continuum. In *Telemanipulator and telepresence technologies* (Vol. 2351, pp. 282-292). Spie.

Palmer, D. H. (1999). Exploring the link between students' scientific and nonscientific conceptions. *Science education*, *83*(6), 639-653.

Sahin, D., & Yilmaz, R. M. (2020). The effect of Augmented Reality Technology on middle school students' achievements and attitudes towards science education. *Computers & Education*, *144*, 103710.

Syawaludin, A. Gunarhadi, & Rintayati, P.(2019). Development of augmented reality-based interactive multimedia to improve critical thinking skills in science learning. *International Journal of Instruction*, *12*(4), 331-344.

Walczak, K., Wojciechowski, R., & Cellary, W. (2006, November). Dynamic interactive VR network services for education. In *Proceedings of the ACM symposium on Virtual reality software and technology* (pp. 277-286).

Wellcome, T. (2015). Primary priority: How supporting teachers makes science exciting.

Winkler, T., Kritzenberger, H., & Herczeg, M. (2002). Mixed reality environments as collaborative and constructive learning spaces for elementary school children. Proceedings of World Conference on Educational Multimedia Hypermedia and Telecommunications

Wu, H. K., Lee, S. W. Y., Chang, H. Y., & Liang, J. C. (2013). Current status, opportunities and challenges of augmented reality in education. *Computers & education*, *62*, 41-49.

Yap, C. L., Karunagharan, J. K., Leong, J. C. K., Liao, I. Y., & Lee, H. S. (2023, June). Developing Augmented Reality Mobile App for Learning Nucleophilic Substitution Reaction Mechanisms in Organic Chemistry: User Perception and Experience. In *2023 4th International Conference on Education, Knowledge and Information Management (ICEKIM 2023)* (pp. 1177-1185). Atlantis Press.

Author Information

Dr. Vinod Kumar Kanvaria
(ORCID iD- 0000-0001-6801-1652)
Associate Professor (Vinodpr111@gmail.com)
Affiliation- Department of Education, University of Delhi, Delhi, India

Gunjan
(ORCID iD- 0009-0008-5828-7477) Corresponding author-
M.Ed. Student (Gunjansagar21@gmail.com)
Affiliation- Department of Education, University of Delhi, Delhi, India