Research Article

Effect of Augmented Reality-Based Science Content on Learning Achievement among Secondary Level Students

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Abstract

Today teachers are dealing with generation alpha, the most technology-supplied generation ever. Generation Alpha is a cohort born entirely in the 21st century and therefore a confident group of digital natives. This means for dealing with them teachers must be prepared for learning how to adopt new technologies and blend them into teaching as these students prefer digital resources and the gamification of education. Using digital resources play an important role in dissolving the boundaries of classrooms and providing an opportunity for students to have experiential learning and promoting problem-solving. In the present paper ePathshala AR (Augmented Reality) Mobile Application has been used to teach AR-based science content to students of class ninth of Dholpur District, Rajasthan to study its effectiveness upon achievement in science. This mobile application is an initiative of NCERT under the aegis of the Ministry of Education, with the caption making Education Experimental. The method employed for the study was experimental with two groups of randomised matched subject pre-test and post-test design. The study was done on 74 ninth-grade students. Results of the study indicated that students in the experimental group not only showed their interest in learning with this application but also a significant effect has been found in their achievement in science as compared to the control group. Considering these findings, the investigator supports the use of ePathshala AR mobile application for a better understanding of scientific concepts among students.

Keywords: Augmented Reality, generation Alpha, learning achievement, ePathshala AR Application, Mobile Application

Introduction

Learning by doing is considered one of the best methods of knowledge construction and gaining insights into abstract concepts in science. When students read science textbooks they encounter several two-dimensional figures and illustrations of different scientific concepts, processes etc. which require imagination to visualize the concept, as some complex concepts require the third dimension to gain a better understanding. Technological advancements in recent years have modified and broadened learning and teaching methods.

Augmented Reality (AR) technology digitally enhances the content of the book by superimposing three-dimensional simulated models over existing figures of the textbook and making it interactive which naturally catches the attention and interest of learners. With this technology students not just read or memorise content in a book but also interact and learn concepts by directly experimenting. The present study used NCERT's ePathshala AR mobile application to teach AR-based science content to ninth-grade students.

Generation Alpha students have a

natural inclination towards digital gadgets and technology-embedded learning models (Prensky, 2001) so, with them using AR based textbooks is an additional advantage for holding their interest and attention in class. In the present study the investigator attempts to use an experiential, student-centric and interactive approach to teaching science via ePathshala AR (Augmented Reality) Mobile Application. This mobile application has selective AR content for class ninth and tenth only. Class ninth has been selected by randomly drawing a lottery for the present study. From class ninth science textbook content from five chapters has been incorporated in this mobile application, out of which three chapters one each from biology, physics and chemistry have been included in the study. Since this ePathshala app uses AR technology with an English medium science textbook of class ninth, so present study was delimited to ninth class students of English medium schools of Dholpur District. During teaching the concept the students of the experimental group were demonstrated how to use AR application via mobile over different figures provided in the textbook that showed the data linked to these figures from the AR database uploaded on the application and enabled them to gain better visualisation and digital experience of the concept. This study intended to determine how science content designed with AR-based applications affected students' learning achievement before and after treatment.

Review of Literature

A number of studies have revealed that AR-based applications affected teaching learning in various disciplines ranging from mathematics which require abstract visualization of concepts, promoting reading and comprehension skills and to science courses including several simulated activities and experiments (Munoz et al, 2015; Chao and Chang, 2018; Abas & Zaman, 2011; Billinghurst & Dunser, 2012, Chen & Wang, 2015). AR technology is more effective as compared to traditional book-based learning (Sin et al, 2010). Lindgren et al (2011) in their study found that AR-based content when compared with computer-based teaching also showed positive results towards the effectiveness of AR technology in education. Chang et al (2011) concluded that the learning process holds more attention for students after using AR technology. Chiang et al (2014) supported the use of AR based mobile learning systems for science content with students in grade fourth in Taiwan. When employed with primary-level students AR-based applications have been found to increase the academic achievement of learners (Contero & Lopez, 2013; Petrov & Atanasova,2020). Muhammad et al (2021) investigated the effectiveness of AR-based learning materials for primary school children in terms of learning performance, motivation, attitude and behaviour towards different methods of learning, the findings favoured AR-based learning techniques enhanced students' learning motivation and performance compared to the non-AR learning methods. Khan et al, 2019 analyzed the impact of an AR Application on the learning motivation of undergraduate health science students and established that using an AR mobile application increased the learning motivation of students.

AR based applications also establish a positive attitude towards learning (Karagozlu et al, 2019; Sahin and Yilmaz, 2020). Cetin & Turkan (2021) investigated the effect of AR-based applications on achievement and attitude towards science courses in distance education and found a significant increase in both. Eldokhny & Drwish (2021) tried to study the effectiveness of AR in

Online Distance Learning at the time of Covid-19 Pandemic and reported that AR was more effective in promoting academic achievement as well as skill acquisition in virtual classrooms as compared to virtual classrooms that did not use AR in online distance learning.

Objectives of Study

The present study purports to fulfill the following objectives –

- To study the effect of AR-based science content on the learning achievement of ninth-class students.
- To study the effect of AR-based science content on different cognitive areas of learning achievement of ninth-class students.

Hypothesis of Study

The following null hypotheses have been stated

- There is no significant difference between the mean scores of science learning achievement of students of control and experimental groups.
- There is no significant difference between the mean scores of different cognitive areas of science learning achievement of students of control and experimental groups.

Material and Methods

The present study employed an experimental method with two groups of randomized matched subjects, pretest–posttest design to test the effect of the AR-based science content using AR ePathshala app on the science learning achievement of students. Pre-test was administered to both control and experimental groups to find out the homogeneity between the groups. The experimental group was exposed to treatment with AR-based science content via AR ePathshala mobile app while the control group was treated with a traditional book-based method of teaching. Post-test was applied to determine the effectiveness of the treatment. Experimental design patterns followed in the study and variables included in the study have been depicted in table 1 and 2.

Table-1: Experimental design of the Study

Randomly Assigned Groups after Matching	Pre-Test	Independent Variable	Post Test
Experimental	Self-Made Achievement Test of Science	Teaching AR-based science content via AR ePathshala mobile app	Self-Made Achievement Test of Science
Control	Self-Made Achievement Test of Science	Teaching through traditional method	Self-Made Achievement Test of Science

Table-2: Variables of the study

Independent Variable	Dependent Variable	Intervening Variable	
		Controlled	**Moderate**
Exposure to AR-based Science Content	*Traditional Teaching*	• *Grade* • *Age* • *Intelligence* • *Socio-economic status* • *Duration of Instruction* • *Teacher* • *Content*	*Gender*

Data Gathering Tools

The following standardized tools have been used in study:

- Socio-Economic Status Scale (RL Bhardwaj, 2006): This scale envisages to determine nine types of statuses namely social status (ascribed), social status (achieved), social status (as a whole) consisting 7 items (areas) like family, social, education, professional, property, monthly income and caste perspective. The reliability of the test has been calculated by the test and re-rests method. The scale was administered on a sample of 200 students and was re-administered on the same sample. The correlation between the two scores was calculated by the Spearman Brown formula and was found to be 0.76.
- Culture Fair Test of Intelligence (Scale 2, Form A) prepared by RN Singh and SD Kapoor (1999) (Indian Adaptation of Cattell's Culture Fair Intelligence Test): This is a nonverbal test of intelligence where the subject has to perceive relationships in shapes and figures. It has four sub-tests, consisting of incomplete progressive series, classification, matrices and conditions. The reliability of the test is 0.76, calculated using the split-half method. The validity is calculated by calculating direct correlations with other tests of general intelligence and is found to be 0.81.
- Self-Made Achievement Test of Science: For measuring learning achievement in Science a self-made achievement Test in Science has been used. The test has been prepared by the investigator in line with the opinions of subject experts. The final test consisted of 40 items after preliminary tryouts and item analysis. The blueprint of the test is given in table 3.

Table-3: Blue Print of Self-Made Achievement in Science

Objectives	Knowledge		Understanding				Application						Total	
Type of Question	Objective		Short Ans	Objective			Short Answer			Objective				
Content	E	A	A	E	A	D	E	A	D	E	A	D	Marks	Questions
Building Blocks of Living Organism									2(1)			1(1)	3	2
Prokaryotic cell											1(1)	1(1)	2	2
Animal cell and its organelles										1(1)	1(3)	1(1)	5	5
Plant Cell and its organelles					1(1)					2(1)		1(1)	4	3
Colloidal Sol^{n} & Tyndall Effect				1(1)			2(1)						3	2
Separation of Components of Mixture	1(1)				1(2)				2(1)				5	4
Evaporation, Sublimation				2(1)									2	1
Distillation, Chromatography					2(1)			2(1)					4	2
Separation of Components of Air	1(1)		2(1)									2(1)	5	3
Water Works water purification system				1(1)									1	1
Production & Propagation of sound	1(1)												1	1
Sound needs a medium to travel	1(1)								2(1)				3	2
Sound waves are longitudinal				1(1)	1(1)								2	2
Characteristics of sound wave				1(2)	1(1)								3	3
Reflection of sound						1(1)							1	1
Applications of Ultrasound	1(2)	1(1)			1(1)								4	4
Sonar	1(2)												2	2
TOTAL (MARKS)	1(8)	1(1)	2(1)	1(5) 2(1)	1(6) 2(1)	1(1)	2(1)	2(1)	2(3)	2(1) 1(1)	1(4)	1(4) 2(1)	50	40
TOTAL QUESTIONS	9		1	14			5			11				
E = Easy Item (difficulty index 0.61 to 0.75) A = Average Item (Difficulty Index 0.4 to 0.60) D = Difficult Item (Difficulty Index 0.25 to 0.39)														

- Reliability and Validity of Test: Split-half reliability of test is calculated, which was found to be 0.712 showing fairly good reliability of the test. The face and content validity of the test was assured while preparing the test. Adequate weightage is given to content, learning objectives and difficulty level (Table 4). The opinion of subject experts was taken into consideration while preparing the test and necessary modifications were made accordingly.

Table-4: Weightage given to different areas in Self-made test of Science Achievement

S.N.	AREA OF WEIGHTAGE		Total Number of Items	Percentage
1	CONTENT	Biology (The fundamental Unit of Life)	12	30.0
		Chemistry (Is matter around us pure?)	13	32.5
		Physics (Sound)	15	37.5
2	COGNITIVE AREA	Knowledge	09	22.2
		Understanding	15	37.5
		Application	16	40.0
3	DIFFICULTY LEVEL	Easy	17	42.5
		Average	14	35.0
		Difficult	09	22.5

Data Collection

A total of 74 students from the CBSE board-affiliated English medium school of Dholpur district of Rajasthan constituted the sample of the present study. Table 5 provides details of the sample. For conducting the experiment prior permissions were sought from the school authorities. Firstly, students were randomly assigned to an experimental and control group after matching for intelligence and socio-economic status. According to the time schedule, a two-month programme was given to the experimental and control group. 32 students were assigned in both experimental and control groups. In the experimental group 21 boys and 11 girls were there while the number of girls and boys in the control group was 20 and 12, respectively. Investigator has provided training and necessary guidance to subject teachers to use AR ePathshala mobile application to teach different AR-based science concepts involved in the study. The teacher demonstrated the experimental group about application usage by presenting demos on a projector screen. Students were motivated to practice the science content with this application. The control group performed learning by conventional book-based method, with the guidance of the same teacher. Prior to and after the experiment the Self-made Test of Achievement was administered and the data was collected for further investigations.

Table-5: Sample of the study

Name of School	Students in Experiment Group		Students in Control Group	
	Boys	Girls	Boys	Girls
AVM Convent School	21	11	20	12
	32		32	
Total	74			

Analysis and Interpretation of Data

To test the significance of the stated hypothesis the mean, standard deviation, t-value and significance were calculated (Table 6). From the table, it can be noticed that the calculated t-value of 7.75 is higher than the tabular value of 2.66 ($p<0.01$) at 72 degrees of freedom. This rejected the null hypothesis of no difference between the learning achievement of the control and experimental group. Thus, we can say that the experimental group performed better in the posttest of achievement test of science after being exposed to AR-based science content.

Table-6: Details of t-test conducted for science achievement in different groups

S.N.	Mean Scores of Groups Compared	N	Mean difference	Df	SD	t value
1	Pretest Control Pretest Experimental	37 37	2.01	72	3.12 2.96	1.06
2	Pretest Experimental Posttest Experimental	37 37	13.38	72	2.96 3.33	7.11**
3	Posttest Control Posttest Experimental	37 37	14.57	72	2.79 3.33	7.75**
4	Pretest Control Posttest Control	37 37	0.81	72	3.12 2.79	0.43

*** Values significant at 0.01 level of significance*

Table 7 provides the analyses for the effect of AR-based science content on different cognitive areas of learning. The t values for knowledge $t(72) = 4.14$, $p<0.01$), understanding $t(72) = 3,5$, $p<0.01$) and application $t(72) = 3.79$, $p<0.01$) areas of learning is found to be significant when the mean scores for control and experimental group was compared. It can be concluded that learning with AR-based science content affected knowledge, understanding and application areas of the cognitive domain of learning.

Table-7: t Values for different cognitive areas of learning for the experimental and control group

Cognitive Area of Learning	Group	N	Mean	SD	SE_D	t Value
KNOWLEDGE	Control	37	4.28	2.06	0.871	4.14**
	Experiment	37	7.89	1.75		
UNDERSTANDING	Control	37	8.03	1.45	1.40	3.5**
	Experiment	37	12.93	3.12		
APPLICATION	Control	37	5.62	2.97	2.30	3.79**
	Experiment	37	14.34	3.24		

Conclusion and Discussion

Literature studies revealed that the scope of exploring the effectiveness of mobile AR on students' learning is very vast as the area is insufficiently worked out (Lin et al., 2013 and Ibanez et al., 2014). This study tried to investigate whether AR-based science content has an effect on learning achievement in science of secondary-level students. For studying this science content via AR ePathshala has been presented to experimental group students. From the analyses of data gathered it has been found that AR-based science content affected students' scores positively in science achievement in knowledge, understanding and application areas of the cognitive domain of learning. The results of the study are consistent with previous studies which also found that AR-based instructional approach proved effective in concretizing the abstract concepts of science. (Walczak et al., 2006; Sayed et al., 2011; Özdemir, 2017; Tulgar, 2019) besides affecting achievement the instructions based on the AR approach also kept high motivation levels among students (Singhal et al., 2012; Chiang et al., 2014; Huang & Liaw, 2014; Ibanez et al., 2014; Torregrosa et al., 2015; Solak & Çakır, 2016; Khan et al., 2019). The effectiveness of AR ePathshala in this study can be attributed to the reason that the students involved in the study were digital natives when they were exposed to treatment with AR-based science content via the mobile application, they showed interest in knowing the concept and the interactivity allowed by this type of content motivated students to concretize the concept by interacting with it. AR-based content provides a high sense of reality to the content so this technology helps in concretizing the concept (Ozdemir, 2017).

In this study, students of the experimental group got the opportunity to see an interactive three-dimensional model of different content which held their interest and prepared them ready to learn. This study strongly supports using AR ePathshala app for teaching different content to students. This concept of augmented reality and its usage in education is still not very popular so there is a need to popularize these types of mobile applications that can be easily used by pre-service and in-service teachers to teach abstract concepts to the alpha generation.

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