Research Article

Pre-Service Teachers' Perceptions about Augmented Reality (AR) Applications in Science Learning

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Abstract

The pre-service teachers' perception of augmented reality applications is studied as they are one of the best technologies for making science learning interesting. The main objective is to study the level of pre-service teachers' perception of augmented reality applications in science learning using a normative survey and the sample of pre-service teachers in the Kasaragod and Alappuzha districts were collected through simple random sampling. The tool used for this study is the perception scale, and its reliability is tested through Cronbach's Alpha (0.977) and split-half method (0.948). The content validity is established by consulting the experts and construct validity through factor analysis. The study found that half of the pre-service teacher (58.6 per cent) has a moderate level of perception, 34.3 per cent have a low level, and 7.2 per cent have a high perception of augmented reality applications in science learning. The main conclusions from the study are that pre-service teachers were found to have an insufficient perception of augmented reality applications in science learning. The teacher educators and pre-service teachers should be provided with proper training regarding the appropriate usage of augmented reality applications.

Keywords: Perception, Augmented reality applications, Pre-service teachers, Science learning, etc.

Introduction

In today's digital world, every aspect of our life is influenced by technology, and it plays an enormous role in education. New technologies have emerged, which make the teaching-learning process meaningful and exciting. Augmented reality applications are gaining popularity as it makes learning a joyful experience by providing a multi-sensory experience. Augmented Reality combines virtual objects with real ones or scenes to maximize natural and intuitive user experience in real-time. It is an interactive environment where virtual things enhance real-life experiences. According to Azuma (1997), Augmented Reality must have three characteristics: combining the real and virtual worlds, having real-time user interaction, and being registered in a 3D space. Augmented Reality allows the user to see the natural world and aims to supplement reality without completely immersing the user inside an artificial environment (Kesim & Ozarslan 2012). Digital information, which can be text, audio, images, video, 3D objects, etc., is cloaked in the real world so that it emerges as part of the actual domain. The significant reason for the popularity of AR applications is that it does not segregate the user from the physical environment (Tzima et al., 2019) (Kounavis et al., 2012). Augmented reality applications are very effective in learning science as it helps to understand abstract concepts easier and gives an in-depth understanding of the concepts (Yilmaz, 2021). They also increase students' achievement, contribute to the meaningful learning

of abstract subjects, and increase the student's interest and motivation toward science learning (Yildirim, 2020).

To effectively integrate augmented reality applications in science learning, the teacher should possess adequate techno-pedagogical knowledge, that is, what type of AR apps should be used to teach a particular topic for a certain level of learners. Hence it is essential to give appropriate training to pre-service and in-service teachers regarding the effective integration of augmented reality applications in science learning (Thiyagu, 2021). Most studies focused on students' and teachers' views on the practical usage of augmented reality applications, but the studies on pre-service teachers' views are negligible. Therefore, the investigator attempts to study the perception of pre-service teachers toward augmented reality applications in science learning.

Review of Research Literature

Augmented reality technology has its roots in computer science interface research. (Sutherland et al., 1977) Many science fiction movies like 'The Terminator (1984) and 'RoboCop' (1987) have used the fundamentals of AR. The term" augmented reality" was first used by Tom Caudell, at Boeing in 1990. he was asked to improve the expensive diagrams and to mark devices used to guide workers on the factory floor (Thomas& David 1992). He proposed replacing the large plywood boards that contained each plane's wiring instructions that were individually designed with a head-mounted apparatus that displays a plane's specific schematics through high-tech eye ware and projects them onto multipurpose, reusable boards (Chauhan et al., 2017).

Augmented Reality is technology in which virtual objects are blended with the natural world and they interact with each other. Augmented reality applications are used in several areas, and the most important of these areas is the field of education. AR technology allows combining natural objects and virtual information to increase students' interaction with physical environments and ease their learning. Developing AR applications enables students to learn complex topics in a fun and easy way through virtual reality devices (Lin et al., 2013). Students interact with objects in the virtual environment, which helps them learn more about them (Yildiz, 2021). AR is an apt tool for teaching abstract concepts that do not feature direct observation and examination in science education. Students show positive opinions about using AR applications in science education (Yilmaz, 2021). Sahin& Yilmaz (2020) studied the impact of learning materials developed with augmented Reality (AR) technology on middle school student's achievement and attitudes towards the course and to determine their attitudes towards AR applications. Students in the experimental group had higher levels of achievement and more positive attitudes toward the study than those in the control group. Additionally, the results also revealed that the students preferred to continue the use of AR applications in the future and showed no signs of anxiety when using AR applications. In addition, the academic achievements and attitudes of the students in the experimental group showed a positive, significant, and intermediate correlation.

The research literature review showed innumerable integration of augmented reality applications in education. Some significant projects in integrating AR in education are The Aumentaty project, developed by the Labhuman laboratory (http://www.labhuman.com) at the Polytechnic University of Valencia in Spain. The Build AR project by the HITLabNZ laboratory (http://www.hitlabnz.org) at the University

of Canterbury in New Zeeland. Both projects mentioned above were developed to implement AR in the classrooms by furnishing tools to design educational AR apps. Some of the research projects funded by the European Union, like CONNECT (2005-2007), CREATE (2004), and ARiSE (2006-2008) were focused on integrating informal learning in a learning environment. Researchers have used Aurasma (http://www.aurasma.com) extensively used as a tool in different learning strategies (Parton & Hancock, 2012; Connolly & Hoskins, 2014). Science Center to Go project (http://www.sctg.eu) is one more example of integrating AR into lessons to improve the quality of science education. Magicbook (Billinghurst, Kato, & Poupyrev, 2001) is among the first few integrations of AR in textbooks. This type of AR book can be used as a regular textbook. Still, it has additional features like visualizing virtual content like 3D objects, animations, or videos (Martín-Gutiérrez et al., 2017).

Objectives of the Study

The following are the main objectives of the study.

1. To find out the pre-service teachers' level of perception towards augmented reality applications in science learning.
2. To assess the familiarity of augmented reality applications in science learning among pre-service teachers.

Purpose and Research Questions

This study intends to determine the pre-service teachers' level of perception towards augmented reality applications in science learning. The following research questions were developed based on fulfilling the needs of the objective of the study.

1. What is the level of pre-service teachers' computer skills?
2. How long do the pre-service teachers have experience in using the internet?
3. What is the familiarity of augmented reality applications in science learning among pre-service teachers?
4. What is pre-service teachers' exposure level towards augmented reality applications in the classroom through their teachers' usage?
5. What is the experience level of using augmented reality applications in science learning during internship among the pre-service teachers?
6. What is the level of the pre-service teachers in terms of their familiarity with AR textbooks?
7. What is the level of familiarity with AR tools among the pre-service teachers?
8. What is the pre-service teachers' familiarity with different augmented reality applications?
9. What is the pre-service teachers' opinion of the purpose of using augmented reality applications in science learning?
10. What are the pre-service teachers' opinions on the effective use of augmented reality applications in science learning?
11. What are the pre-service teachers' perceptions of augmented reality applications in science learning?
12. What is the pre-service teachers' level of perception towards augmented reality applications in science learning?

Methods of Research

The study intended to determine the pre-service teachers' level of perception of augmented reality applications in science learning. Therefore, the present study was conducted using the normative survey method.

Population of the Study

In this study, the target population will be the pre-service teachers who are studying the science stream irrespective of the nature of management and universities but located in the Alappuzha and Kasaragod districts, Kerala. For this study, 181 samples were collected using a random sampling technique.

Tool for the Study

The investigator developed a rating scale for finding the pre-service teachers' perception of augmented reality applications in science learning. The tool was prepared after referring to so many reviews of related studies. The researcher discussed fixing her final tool with the supervisor, senior students, and Ph.D. scholars. Format and language, the wording of items used by the researcher were simple, and the respondent could easily follow these items. The investigator used a self-made tool entitled "Perception of Augmented Reality Applications in Science Learning Rating Scale (PARA-SLRS)". The researcher standardized the tool with the help of the supervisor.

Reliability of the Tool

In the present study, the investigator employed Cronbach's Alpha and split-half method to establish the reliability of the tools. The Cronbach's alpha value obtained is 0.977, which indicates a high level of internal consistency of the tool. Therefore, the tool is reliable. The investigator employed a split-half method to establish the 'γ' value of the tools. Then the reliability of the tools was estimated by the Spearman-Brown formula. The Spearman-Brown Coefficient value of the tool is 0.948. Thus, the reliability of the tools was established.

Validity of the Tool

The content validity is established by consulting the experts and construct validity through factor analysis.

Statistical Techniques Used

The investigator used frequency and percentage analysis to describe the data. SPSS Statistics Version 25 was used for analyzing the collected data.

Analysis of Data

Reporting of the findings is organized according to the research questions.

Research Question 1

What is the level of pre-service teachers' computer skills?

Table-1: Analysis of the sample in terms of rating the level of skills with computer

Skills in computer	No. of Pre-service Teachers	Percentage (%)
Beginner	34	23.1
Intermediate	92	62.6
Advanced	21	14.3

The above table (Table 1) presents the sample distribution in terms of their level of skills in using the computer. As seen from the table, 23.1 per cent of the sample is beginners, 62.6 per cent are intermediate, and the remaining 14.3 per cent are advanced computer users. It is seen that more than half [62.6 per cent] of the sample have intermediate skills with the computer. It might be the consequence of integrating ICT in teacher training programs, thus increasing computer skills among pre-service teachers.

Research Question 2

How long do the pre-service teachers have experience in using the internet?

Table-2: Analysis of the sample *regarding* their experience in using internet

Years of Experience	No. of Pre-service Teachers	Percentage (%)
<3 years	1	0.6
3-5 years	27	14.9
Above 5 years	153	84.5

The above table (Table 2) presents the sample distribution in terms of their experience in using the internet. As seen from the table, 84.5 per cent of the sample has over five years of experience in using the internet, 14.9 per cent have been using the internet for 3-5 years, and the remaining 0.6 per cent has less than three years of experience. It is clear from the findings of the table that the majority of the sample [84.5 per cent] have above five years of experience using the internet. As a result of the revolution in telecommunications in India, internet services have become cheaper, and internet exposure significantly increased during the pandemic period. Thus, the majority of pre-service teachers have experience in using the Internet.

Research Question 3

What is the familiarity of augmented reality applications in science learning among pre-service teachers?

Table-3: Analysis of the sample regarding their familiarity of AR applications in science learning

Familiarity of AR apps	No. of Pre-service Teachers	Percentage (%)
Yes	89	49.2
No	92	50.8

The above table (Table 3) presents the sample distribution regarding their familiarity with augmented reality applications in science learning. As seen from the table, 49.2 per cent of the samples are familiar with augmented reality applications in science learning, and 50.8 per cent responded that they are not familiar with augmented reality applications in science learning. It is clear from the table that half of the study samples are not familiar with augmented reality applications in science learning. It may result from a lack of proper training for the pre-service teachers in augmented reality applications in science learning.

Research Question 4

What is pre-service teachers' exposure level towards augmented reality applications in the classroom through their teachers' usage?

Table-4: Analysis of the sample *regarding* their teacher's usage of the AR applications

Teacher's Use of AR	No. of Pre-service Teachers	Percentage (%)
Yes	45	24.9
No	136	75.1

The above table (Table 4.) presents the sample distribution regarding the teacher's use of AR applications in the classroom. As seen from the table, 24.9 per cent of the sample responded that their teachers use augmented reality applications in their class, and 75.1 per cent responded that their teachers do not use augmented reality applications in their class. The majority [75.1 per cent] of the pre-service teachers are not made familiar with augmented reality applications by their teachers. It may be due to teacher educators' lack of awareness about augmented reality applications.

Research Question 5

What is the experience level of using augmented reality applications in science learning during internship among the pre-service teachers?

Table-5: Analysis of the sample regarding their experience of using AR apps during internship

Usage in Internship	No. of Pre-service Teachers	Percentage (%)
Yes	34	18.8
No	147	81.2

The above table (Table 5.) presents a distribution sample regarding their experience using augmented reality applications in science learning during their internship. As seen from the table, 18.8 per cent of the sample used augmented reality applications in science learning during their internship, and the majority of the samples, 81.2 per cent, have not used augmented reality applications in their internship. Even though 49.2 per cent [Table 3] of pre-service teachers are familiar with augmented reality applications, only 18.8 per cent use AR in their internship, indicating they are not confident in using it. It may result from not properly training pre-service teachers about the effective integration of AR applications in science lesson plans.

Research Question 6

What is the level of the pre-service teachers in terms of their familiarity with AR textbooks?

Table-6: Analysis of the sample regarding rating the level of their familiarity of AR textbooks

AR textbooks familiarity	No. of Pre-service Teachers	Percentage (%)
Yes	22	12.2
No	159	87.8

The above table (Table 6) presents the sample distribution regarding their familiarity with AR textbooks. As seen from the table, 12.2 per cent of the samples are familiar with AR textbooks, and the majority of the samples, 87.8 per cent, are unfamiliar with AR textbooks. It indicates that although 49.2 per cent [Table 3] of pre-service teachers are familiar with augmented reality applications, they are unaware of various other aspects of AR applications in science learning. It may be due to a lack of training in pre-service teachers about augmented reality applications.

Research Question 7

What is the level of familiarity with AR tools among the pre-service teachers?

Table-7: Analysis of the sample regarding rating the level of their familiarity of AR tools

Familiarity of AR tools	No. of Pre-service Teachers	Percentage (%)
Head – mounted Displays	28	15.5
Handheld Displays	23	12.7
Spatial Displays	21	11.6
Pinch Gloves	5	2.8
Others	26	14.4
None of these	107	59.1

The above table (Table 7) presents the sample distribution in terms of their familiarity with AR tools. As seen from the table, 15.5 per cent are familiar with head-mounted displays, 12.7 per cent are familiar with handheld displays, 11.6 per cent are familiar with spatial displays, 2.8 per cent is familiar with pinch gloves, 14.4 per cent are familiar with other AR tools, and remaining 59.1 per cent are not familiar with any of these AR tools. It specifies that although 49.2 per cent [Table 3] of pre-service teachers are familiar with augmented reality applications, they are unaware of various other aspects of AR applications in science learning due to a lack of proper training given to pre-service teachers about augmented reality applications.

Research Question 8

What is the pre-service teachers' familiarity with different augmented reality applications?

Table-8: Analysis of the sample regarding the level of their familiarity of different AR Apps

AR Applications	Not Used		Intermediate		Advanced	
	F	%	F	%	F	%
ARLOOPA	161	89	16	8.8	4	2.2
Assembler EDU	163	90.1	17	9.4	1	.6
Google expeditions	128	70.7	47	26	6	3.3
Autumn visualizer	159	87.8	20	11	2	1.1
AR VR Molecules	156	86.2	23	12.7	2	1.1

Anatomy 4D	147	81.2	25	13.8	9	5
Science AR	142	78.5	29	16	10	5.5
Elements 4D	149	82.3	27	14.89	5	2.8

The above table (Table 8) presents the sample distribution regarding their familiarity with different augmented reality applications. As seen from the table, 89 per cent have not used ARLOOPA, 8.8 per cent have intermediate familiarity, and only 2.2 per cent have advanced knowledge. In the case of Assemblr EDU, 90.1 have not used it, 9.4 per cent have intermediate familiarity, and only 0.6 per cent have advanced knowledge. 70.7 per cent have not used google expeditions, 26.0 per cent have intermediate familiarity, and only 3.3 per cent have advanced knowledge. In the Autumn visualizer, 87.8 per cent have not been used, 11.0 per cent had intermediate familiarity, and only 1.1 per cent have advanced knowledge. 86.2 per cent have not used AR VR molecules, 12.7 per cent have intermediate familiarity, and only 1.1 per cent has advanced knowledge. 81.2 per cent have not used Anatomy 4D, 13.8 per cent have intermediate familiarity, and only 5.0 per cent have advanced knowledge. In the case of Science AR, 78.5 per cent have not used it, 16 per cent have intermediate familiarity, and only 5.5 per cent have advanced knowledge. In the case of Elements 4D, 82.3 per cent have not used it, 14.9 per cent have intermediate familiarity, and only 2.8 per cent have advanced knowledge. It is seen from the table that the majority of the pre-service teachers are not familiar with specific augmented reality apps in science learning. It indicates that pre-service teachers' knowledge about augmented reality applications in science learning is limited.

Research Question 9

What is the pre-service teachers' opinion of the purpose of using augmented reality applications in science learning?

The sample was asked to rate their opinion about the purpose of using augmented reality applications in science learning. They were given the following four statements and asked to rate them; multiple responses were allowed.

1. Helps in understanding abstract concepts
2. In depth understanding of scientific concepts
3. Provides multi-sensory learning experience
4. Promotes active learning

Table-9: Analysis of the sample regarding their opinion of purpose of using AR Apps

Purpose of using AR apps	F	%
Helps in understanding abstract concepts	76	42
In depth understanding of scientific concepts	85	47
Provides multi-sensory learning experience	107	59.1
Promotes active learning	117	64.6

The above table (Table 9) presents the sample distribution in terms of rating their opinion of the purpose of using augmented reality applications in science learning. Forty-two per cent of pre-service teachers believe that the purpose of using augmented reality applications in science learning is because it helps in understanding abstract concepts. Forty-seven per cent believe that it helps in-depth understanding of scientific concepts and 59.1 per cent thinks that it provides a multi-sensory learning experience. The majority of 64.6 per cent pre-service teachers think that it promotes active learning. It shows that even though the pre-service teachers' familiarity with various AR tools or AR apps is limited. They do have a favourable opinion about the purpose of using AR applications in science learning.

Research Question 10

What are the pre-service teachers' opinions on the effective use of augmented reality applications in science learning?

The sample was asked to rate their opinion about the effective use of augmented reality applications in science learning. They were given the following three statements and asked to rate them; multiple responses were allowed.

1. Selecting the appropriate AR applications
2. Effective integration of AR applications in the lesson
3. Using Interactive AR applications ensuring active student participation

Table-10: Analysis of the sample regarding their effective use of AR Apps in Science Learning

Effective use of AR apps in science learning	F	%
Selecting the appropriate AR applications	87	48.1
Effective integration of AR applications in the lesson	113	62.4
Using Interactive AR apps ensuring active student participation	121	66.9

The above table (Table 10) presents the sample distribution in terms of rating the level of their opinion about the effective use of augmented reality applications in science learning. 48.1 per cent of pre-service teachers believe that the effective use of augmented reality applications in science learning is because of selecting the appropriate AR applications. 62.4 per cent thinks that the effective use of augmented reality applications in science learning is because of the successful integration of AR applications in the lesson. The majority, 66.9 per cent, think that using augmented reality applications in science learning is effective because interactive AR applications ensure active student participation. It indicates that the pre-service teachers have strong opinions about using augmented applications effectively in science learning.

Research Question 11

What are the pre-service teachers' perceptions of augmented reality applications in science learning?

Table-11: Analysis of sample regarding of the perception towards AR apps in science learning

Statements	SD	DA	N	A	SA
	F (%)	F (%)	F (%)	F (%)	F (%)
I feel augmented reality applications make the science class more interesting.	09(5.5)	13(7.2)	25(13.8)	49(27.1)	85(47.0)
I feel AR applications help learners to understand abstract science concepts better.	04(2.2)	23(12.7)	15(8.3)	85(47)	54(29.8)
AR applications help in-depth understanding of scientific concepts.	6(3.3)	11(6.1)	35(19.3)	73(40.3)	56(30.9)
I believe that the practical use of AR applications can significantly change the science learning process.	10(5.5)	16(8.8)	19(10.5)	78(43.1)	58(32)
AR applications create a joyful learning experience for learners.	9(5)	12(6.6)	23(12.7)	73(40.3)	64(35.4)
I think AR applications bring significant change to science learning.	2(1.1)	23(12.7)	25(13.8)	79(43.6)	52(28.7)
I feel AR applications promote learner-centred learning	3(1.7)	10(5.5)	49(27.1)	78(43.1)	41(22.7)
AR applications inculcate various science process skills.	7(3.9)	22(12.2)	29(16)	88(48.6)	35(19.3)
I will use AR applications in the future of my science teaching and learning	11(6.1)	12(6.6)	29(16)	84(46.4)	45(24.9)
I believe AR application usage results in a high level of achievement in science learners.	9(5)	23(12.7)	41(22.7)	73(40.3)	35(19.3)
I feel AR application usage creates a positive attitude toward science learning.	11(6.1)	12(6.6)	32(17.7)	84(46.4)	42(23.2)
I think AR applications reduce the scientific anxiety of learners.	17(9.4)	29(16)	42(23.2)	63(34.8)	30(16.6)
I believe AR applications can replace paper-based textbooks, physical models, posters, and printed manuals in future.	13(7.2)	23(12.7)	58(32)	59(32.6)	28(15.5)

I feel we should get more opportunities to use AR applications in our internship.	4(2.2)	16(8.8)	44(24.3)	73(40.3)	44(24.3)
I feel we need special training to use AR applications in our classroom teaching.	12(6.6)	16(8.8)	23(12.7)	71(39.2)	59(32.6)
I believe AR applications are an optimal tool for teaching abstract topics.	10(5.5)	18(9.9)	30(16.6)	88(48.6)	35(19.3)
AR applications help the students to self-evaluate.	10(5.5)	25(13.8)	49(27.1)	74(40.9)	23(12.7)
I believe AR technology may help teach students with different learning styles.	7(3.9)	11(6.1)	40(22.1)	91(50.3)	32(17.7)
I feel AR applications facilitate the integration of theory and practice.	7(3.9)	16(8.8)	33(18.2)	96(53)	29(16)
AR applications help evaluate the various aspects of the students, like creativity, critical thinking, etc.	7(3.9)	20(11)	50(27.6)	76(42)	28(15.5)
AR applications help to identify the effectiveness of class in the context of students' perception, engagement, interactivity, and comfort with the activity.	8(4.4)	16(8.8)	39(21.5)	94(51.9)	24(13.3)
AR applications provide a multi-sensory learning experience.	10(5.5)	13(7.2)	32(17.7)	76(42)	50(27.6)
I feel AR applications increase students' attention span compared to traditional methods.	7(3.9)	21(11.6)	32(17.7)	84(46.4)	37(20.4)
AR applications increase student engagement in the classroom.	8(4.4)	17(9.4)	43(23.8)	65(35.9)	48(26.5)
I believe AR applications increase long-term memory retention of scientific concepts.	8(4.4)	15(8.3)	35(19.3)	73(40.3)	50(27.6)
I feel AR applications increase students' motivation for science learning.	5(2.8)	16(8.8)	28(15.5)	88(48.6)	44(24.3)
Using AR applications for evaluation reduces exam stress among students.	5(2.8)	30(16.6)	36(19.9)	81(44.8)	29(16)

I feel AR application is effective in teaching 3D spatial and kinesthetic content.	7(3.9)	15(8.3)	35(19.3)	81(44.8)	43(23.8)
I feel AR applications increase student participation in science learning activities.	8(4.4)	13(7.2)	42(23.2)	86(47.5)	32(23.8)

The above table (Table 11) presents the sample analysis regarding perception towards augmented reality applications in science learning.

AR 1: I feel augmented reality applications make the science class more interesting.

Among 181 pre-service teachers, 27.1 per cent agreed, and 47 per cent strongly agreed that they feel augmented reality applications make the science class more interesting. 7.2 per cent disagree, and 5 per cent strongly disagree with this statement.13.8 per cent gave neutral responses.

AR 2: I feel AR applications help learners to understand abstract science concepts better.

Among 181 pre-service teachers, 47 per cent agreed, and 29.8 per cent strongly agreed that they feel AR applications help learners to understand abstract science concepts better. 12.7 per cent disagree, and 2.2 per cent strongly disagree with this statement.8.3 per cent gave neutral responses.

AR 3: AR applications help an in-depth understanding of scientific concepts.

Among 181 pre-service teachers, 40.3 per cent agreed, and 30.9 per cent strongly agreed that they feel AR applications help an in-depth understanding of scientific concepts. 6.1 per cent disagree, and 3.3 per cent strongly disagree with this statement.19.3 per cent gave neutral responses.

AR 4: I believe that the effective usage of AR applications can make significant changes in the science learning process

Among 181 pre-service teachers, 43.1 per cent agreed, and 32 per cent strongly agreed that they believe that the effective usage of AR applications can make significant changes in the science learning process. 8.8 per cent disagree, and 5.5 per cent strongly disagree with this statement.10.5 per cent gave neutral responses.

AR 5: AR applications create a joyful learning experience for learners.

Among 181 pre-service teachers, 40.3 per cent agreed, and 35.4 per cent strongly agreed that they feel that AR applications create a joyful learning experience for the learners. 6.6 per cent disagree, and 5.0 per cent strongly disagree with this statement.12.7 per cent gave neutral responses.

AR 6: I think AR applications bring significant change to science learning.

Among 181 pre-service teachers, 43.6 per cent agreed, and 28.7 per cent strongly agreed that they feel that AR applications bring significant change to science learning. 12.7 per cent disagree, and 1.1 per cent strongly disagree with this statement.13.8 per cent gave neutral responses.

AR 7*:* I feel AR applications promote learner-centred learning

Among 181 pre-service teachers, 43.1 per cent agreed, and 22.7 per cent strongly agreed that they think that AR applications promote learner-centred learning. 5.5 per cent disagree and 1.1 per cent strongly disagree with this statement.27.1 per cent gave neutral responses.

AR 8: AR applications inculcate various science process skills.

Among 181 pre-service teachers, 48.6 per cent agreed, and 19.3 per cent strongly agreed that they feel that AR applications inculcate various science process skills.12.2 per cent disagree and 3.9 per cent strongly disagree with this statement.16 per cent gave neutral responses.

AR 9: I will use AR applications in the future of my science teaching and learning

Among 181 pre-service teachers, 45.4 per cent agreed, and 24.9 per cent strongly agreed that they would use AR applications in the future of their science teaching and learning.6.6 per cent disagree, and 6.1 per cent strongly disagree with this statement.16 per cent gave neutral responses.

AR 10: I believe AR application usage results in a high level of achievement in science learners.

Among 181 pre-service teachers, 40.3 per cent agreed, and 19.3 per cent strongly agreed that AR application usage results in a high level of achievement in science learners.12.7 per cent disagree, and 5 per cent strongly disagree with this statement.22.7 per cent gave neutral responses.

AR 11: I feel AR application usage creates a positive attitude to the learners toward science learning.

Among 181 pre-service teachers, 46.4 per cent agreed, and 23.2 per cent strongly agreed that AR application usage creates a positive attitude toward science learning. 6.6 per cent disagree, and 6.1 per cent strongly disagree with this statement.17.7 per cent gave neutral responses.

AR 12: I think AR applications reduce the scientific anxiety of learners.

Among 181 pre-service teachers, 34.8 per cent agreed, and 16.6 per cent strongly agreed that AR applications reduce the scientific anxiety of the learners. 16 per cent disagree, and 9.4 per cent strongly disagree with this statement.23.2 per cent gave neutral responses

AR 13: I believe AR applications can replace paper-based textbooks, physical models, posters, and printed manuals in future.

Among 181 pre-service teachers, 32.6 per cent agreed, and 15.5 per cent strongly agreed that AR applications have the potential to replace paper-based textbooks, physical models, posters, and printed manuals. 12.7 per cent disagree, and 7.2 per cent strongly disagree with this statement.32 per cent gave neutral responses.

AR 14: We should get more opportunities to use AR applications in our internship.

Among 181 pre-service teachers, 40.3 per cent agreed, 24.3 per cent strongly agreed that they should get more opportunities to use AR applications in the internship, 8.8 per cent disagreed, and 2.2 per cent strongly disagreed. 24.3 per cent gave neutral responses.

AR 15: We need special training to use AR applications in classroom teaching.

Among 181 pre-service teachers, 39.2 per cent agreed, and 32.6 per cent strongly agreed that they need special training to use AR applications in the classroom teaching 8.8 per cent disagreed, and 6.6 per cent strongly disagreed with this statement.12.7 per cent gave neutral responses.

AR 16: I believe AR applications are optimal for teaching abstract topics.

Among 181 pre-service teachers, 48.6 per cent agreed, and 19.3 per cent strongly agreed that they believe AR applications are an optimal tool for teaching abstract topics. 9.9 per cent

disagree, and 5.5 per cent strongly disagree with this statement.16.6 per cent gave neutral responses.

AR 17: AR applications help the students to self-evaluate.

Among 181 pre-service teachers, 40.9 per cent agreed, 12.7 per cent strongly agreed that AR applications help the students to self-evaluate, 13.8 percent disagreed, and 5.5 per cent strongly disagreed with this statement. 27.1 per cent gave neutral responses.

AR 18: AR technology may help teach students with different learning styles.

Among 181 pre-service teachers, 50.3 per cent agreed, and 17.7 per cent strongly agreed that AR technology might help to teach students with different learning styles. 6.1 per cent disagree, and 3.9 per cent strongly disagree with this statement. 22.1 per cent gave neutral responses.

AR 19: I feel AR applications facilitate the integration of theory and practice.

Among 181 pre-service teachers, 53 per cent agreed and 16 per cent strongly agree that AR applications facilitate the integration of theory and practice. 8.8 per cent disagree, and 3.9 per cent strongly disagree with this statement. 18.2 per cent gave neutral responses

AR 20*:* AR applications help evaluate the various aspects of the students, like creativity, critical thinking, etc.

Among 181 pre-service teachers, 42 per cent agreed, and 15.5 per cent strongly agreed that AR applications help evaluate the various aspects of the students, like creativity, critical thinking, etc. 11 per cent disagree and 3.9 per cent strongly disagree with this statement. 27.6 per cent gave neutral responses.

AR 21: AR applications help to identify the effectiveness of class in the context of students' perception, engagement, interactivity, and comfort with the activity.

Among 181 pre-service teachers, 51.9 per cent agreed, and 13.3 per cent strongly agreed that AR applications help identify the class's effectiveness in the context of students' perception, engagement, interactivity, and comfort with the activity. 8.8 per cent disagree, and 4.4 per cent strongly disagree with this statement. 21.5 per cent gave neutral responses.

AR 22: AR applications provide a multi-sensory learning experience.

Among 181 pre-service teachers, 42 per cent agreed, and 27.6 per cent strongly agreed that they feel AR applications provide a multi-sensory learning experience.7.2 per cent disagree, and 5.5 per cent strongly disagree with this statement. 17.7 per cent gave neutral responses.

AR 23*:* I feel AR applications increase students' attention span compared to traditional methods.

Among 181 pre-service teachers, 46.4 per cent agreed, and 20.4 per cent strongly agreed that they feel AR applications increase students' attention span compared to traditional methods .11.6 per cent disagree, and 3.9 per cent strongly disagree with this statement. 17.7 per cent gave neutral responses.

AR 24: AR applications increase student engagement in the classroom.

Among 181 pre-service teachers, 35.9 per cent agreed, and 26.5 per cent strongly agreed that they feel AR applications increase student engagement in the classroom. 9.4 per cent disagree, and 4.4 per cent strongly disagree with this statement. 23.8 per cent gave neutral responses.

AR 25: I believe AR applications increase long-term memory retention of scientific concepts.

Among 181 pre-service teachers, 40.3 per cent agreed, and 27.6 per cent strongly agreed that they believe AR applications increase long-term memory retention of scientific concepts. 8.3 per cent disagree, and 4.4 per cent strongly disagree with this statement.16 per cent gave neutral responses.

AR 26: AR applications increase students' motivation for science learning.

Among 181 pre-service teachers, 48.6 per cent agreed, and 24.3 per cent strongly agreed that they feel AR applications increase motivation for science learning. 8.8 per cent disagree, and 2.8 per cent strongly disagree with this statement.15.5 per cent gave neutral responses.

AR 27: Using AR applications for evaluation reduce exam stress among the students.

Among 181 pre-service teachers, 44.8 per cent agreed, and 16 per cent strongly agreed that using AR applications for evaluation reduces exam stress among students. 16.6 per cent disagree, and 2.8 per cent strongly disagree with this statement.19.9 per cent gave neutral responses.

AR 28: AR application effectively teaches 3D spatial and kinesthetic content.

Among 181 pre-service teachers, 44.8 per cent agreed, and 23.8 per cent strongly agreed that AR application effectively teaches 3D spatial and kinesthetic content. 8.3 per cent disagree, and 3.9 per cent strongly disagree with this statement.19.3 per cent gave neutral responses.

AR 29: I feel AR applications increase student participation in science learning activities.

Among 181 pre-service teachers, 47.5 per cent agreed, and 17.7 per cent strongly agreed that AR applications increase student participation in science learning activities. 7.2 per cent disagree, and 4.4 per cent strongly disagree with this statement.23.2 per cent gave neutral responses. When analyzing the individual response regarding augmented reality applications in science learning, some pre-service teachers responded neutrally, and some disagreed with certain aspects of augmented reality applications. Some expressed their strong agreement with some features of augmented reality applications, and a few students responded as strongly disagreed with some particular statements. After analyzing the complete response, the output showed that most pre-service teachers moderately perceive augmented reality applications in science learning. The remaining students have a low-level perception, and a few have a high perception of augmented reality applications in science learning.

Research Question 12

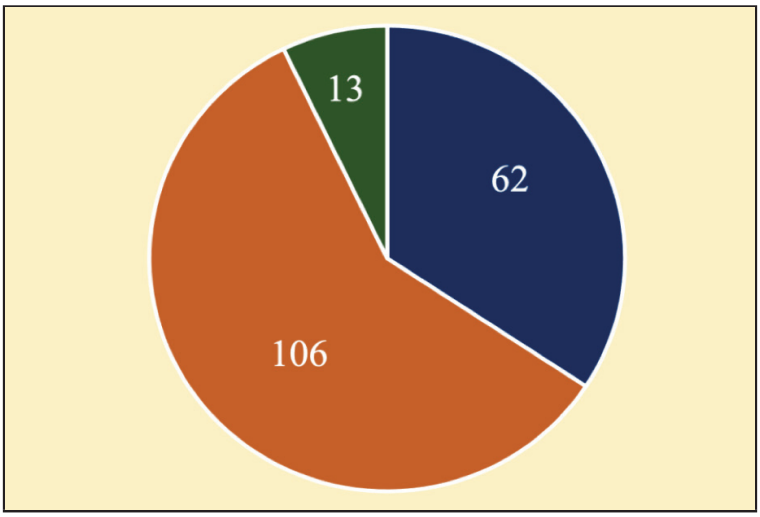
What is the pre-service teachers' level of perception towards augmented reality applications in science learning?

Table-12: Analysis of sample regarding the level of perception towards AR apps in science learning

Perception level on AR Apps	Frequency	Percentage (%)
Low	62	34.3
Moderate	106	58.6
High	13	7.2

The above table (Table 12) presents the sample analysis regarding the level of perception towards augmented reality applications in science learning. As seen from the above table, 62 (34.3 per cent) of the sample have a low level, 106 (58.6 per cent) of the sample have a moderate level, and 13 (7.2 per cent) of the sample have a high level of perception toward augmented reality applications in science learning.

Graph-1: Graph shows the level of perception of pre-service teachers towards AR apps



This study gained more insights into pre-service teachers' perceptions of augmented reality applications in science learning. More than half of the sample (58.6 per cent) has moderate level perception, but there are, however, still 34.3 per cent of Pre-service teachers who have a low level of perception. This can be due to several factors; even though AR applications have been popular worldwide for the last couple of years, it has not been popular in India. It may also be because students do not have access to smartphones and reliable internet services.

In the beginning, operating AR applications required additional equipment like various AR tools. In India, even though smart classrooms are gaining popularity, the availability of AR tools is negligible. Furthermore, the lack of awareness among teacher educators also adds to the low perception among the pre-service teachers. 7.2 per cent of pre-service teachers have a high level of perception towards augmented reality applications in science learning due to the availability of smartphones and reliable internet service.

Recommendations for Future Research

- Future research must focus on pre-service and in-service teachers in special education, as augmented reality applications would enormously help in the teaching-learning process of special children. The teachers should know how to integrate various augmented reality applications successfully according to the needs of the children.
- In the future, the perception of teacher educators to augmented reality applications in science learning can be studied.

- Future research should investigate whether using augmented reality applications in science learning would increase students' interest in science subjects.
- Further studies should be conducted to identify the technical barriers the pre-service teachers might have in integrating augmented reality applications in their classes.
- In the future, a detailed study can be made by using a large sample covering other districts and states, and more variables can also be included.
- Further research will be conducted to determine the influence of augmented reality applications on students' academic performance and behaviour.
- The challenges teachers face while integrating augmented reality applications can be studied in the future.

Conclusions

In the current scenario, ICT-integrated learning is gaining popularity, and many schools are equipped with smart classrooms; the teachers should be proficient in integrating ICT into their lesson plans. In this scenario, the pre-service teachers' perception of augmented reality applications in science learning is studied as augmented reality applications are one of the best technologies for making science learning interesting. The following are the conclusions derived from the study:

- Pre-service teachers were found to have an insufficient perception of augmented reality applications in science learning.
- The pre-service teachers should be allowed to use various augmented reality applications in their internship as it would help them gain confidence to use them in the future.
- The inadequacy of pre-service teachers in identifying various AR apps and AR tools may be because they don't know how to use them.

Following are the educational implications of the study:

- The pre-service teachers should be trained to integrate augmented reality applications in the lesson plan effectively, identify the appropriate science AR apps for a particular concept and student level, and develop AR apps to make them suitable for their lessons.
- Teacher educators should be given special training in integrating various AR apps in their classrooms. They should also teach the pre-service teachers about effectively integrating AR apps into their lesson plans.
- Teacher educators should encourage students to use AR apps in their studies and implement them effectively in their future classes.
- Pre-service teachers should be allowed to use AR apps in their internships. It would give them the confidence to use it in the future.
- This study helps determine the level of perceptions of augmented reality applications in science learning among pre-service teachers.
- This study is significant from a global perspective.

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