Augmented Reality (AR) Technology on Student Engagement: An Experimental Research Study

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Abstract

This experimental research aims to investigate the potential benefits of integrating augmented reality (AR) technology into the classroom setting. The study hypothesizes that the use of AR technology will enhance student engagement and lead to improved learning outcomes. A sample of participants from a local high school will be involved in this research. The research employs a pre-test/post-test design to assess the impact of AR technology on student engagement and learning outcomes. Data will be collected and analysed to determine the effectiveness of AR technology in enhancing classroom education.

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Keywords: Augmented Reality, Classroom, Student, Experimental Research, Learning Outcomes.

Introduction

The advent of augmented reality (AR) technology has opened up new possibilities for enhancing educational experiences in the classroom. AR blends digital information with the real world, creating an interactive and immersive learning environment. This research seeks to explore the impact of AR technology on student engagement and learning outcomes. The hypothesis is that the integration of AR technology in the classroom will positively influence student engagement and ultimately lead to improved learning outcomes.

Hypothesis

H0 (Null Hypothesis): There is no significant difference in student engagement and learning outcomes between a traditional classroom setting and a classroom incorporating AR technology.

H1 (Alternative Hypothesis): The use of AR technology in the classroom significantly enhances student engagement and improves learning outcomes.

Method of the study

Participants: A sample of 100 high school students, aged 14-16, will be selected from a local high school. These students will be randomly assigned to one of two groups: the experimental group (utilizing AR technology) and the control group (traditional classroom setting).

Procedure:

1. Pre-Test: Before the experiment, both groups will undergo a pre-test to assess their baseline levels of engagement and subject knowledge.
2. Experimental Group: The experimental group will attend classes where AR technology will be integrated into the curriculum. The AR technology will include interactive learning materials, 3D visualizations, and virtual simulations.
3. Control Group: The control group will follow the traditional classroom setting, using textbooks and standard teaching methods.
4. Post-Test: After the experiment, both groups will take a post-test to evaluate their learning outcomes and engagement levels.
5. Data Analysis: Statistical analysis, including t-tests and analysis of variance (ANOVA), will be conducted to compare the pre-test and post-test scores of both groups. Qualitative feedback will also be collected through surveys and interviews to gain insights into the students' experiences.

Instruments

A standardized survey questionnaire for qualitative feedback is a valuable way to gain insights into students' experiences with augmented reality (AR) technology in the classroom. Here's a sample questionnaire that you can use as a starting point:

Student Feedback Survey Questionnaire

Dear Participant,

We value your input and would appreciate your honest feedback regarding your experience with augmented reality (AR) technology in the classroom. Your responses will help us improve our educational practices and technology integration.

Demographics:

1. Name (optional):

2. Age:

3. Gender:

4. Grade/Year:

5. How familiar are you with AR technology before participating in this experiment? (Not familiar, Somewhat familiar, Very familiar)

Section 1: Overall Experience

6. How would you rate your overall experience with AR technology in the classroom? (Scale: Very Negative, Negative, Neutral, Positive, Very Positive)

- [ ] Very Negative

- [ ] Negative

- [ ] Neutral

- [ ] Positive

- [ ] Very Positive

7. Please explain the factors that influenced your overall experience with AR technology.

Section 2: Engagement and Learning

8. Did you find AR technology to be engaging for your learning experience? (Yes, No, Unsure)

- [ ] Yes

- [ ] No

- [ ] Unsure

9. Describe specific instances where AR technology helped or hindered your engagement in the classroom.

10. Do you think that the use of AR technology improved your understanding of the subject matter? (Yes, No, Unsure)

- [ ] Yes

- [ ] No

- [ ] Unsure

11. Please provide examples of how AR technology enhanced or hindered your learning.

Section 3: Content and Interactivity

12. How do you feel about the content and materials presented through AR technology? (Scale: Very Dissatisfied, Dissatisfied, Neutral, Satisfied, Very Satisfied)

- [ ] Very Dissatisfied

- [ ] Dissatisfied

- [ ] Neutral

- [ ] Satisfied

- [ ] Very Satisfied

13. Please share your thoughts on the specific AR content or materials you found most useful or least helpful.

14. Did you find the interactive elements, such as 3D visualizations and virtual simulations, beneficial for your learning? (Yes, No, Unsure)

- [ ] Yes

- [ ] No

- [ ] Unsure

15. What interactive features of AR technology do you believe were most effective or could be improved?

Section 4: Suggestions and Improvements

16. Are there any specific features or aspects of AR technology that you think could be improved or added to enhance the classroom experience?

17. What suggestions do you have for educators and developers to make better use of AR technology in the classroom?

Section 5: Additional Comments

18. Is there anything else you would like to share about your experience with AR technology in the classroom?

Section 6: Follow-up Interview

19. Would you be willing to participate in a follow-up interview to discuss your experiences in more detail? (Yes, No, Maybe)

- [ ] Yes

- [ ] No

- [ ] Maybe

Thank you for your feedback! Your input is valuable in helping us understand the impact of AR technology on the classroom experience.

_____End of Questionnaire_____

Here's a standardized set of interview questions to collect qualitative feedback from students regarding their experiences with augmented reality (AR) technology in the classroom:

Student Interview Guide for Qualitative Feedback

Introduction:

1. Thank you for participating in this interview. Your insights are valuable in helping us understand your experiences with AR technology in the classroom. We would like to learn more about your thoughts and perspectives.

Demographics:

2. Can you please share some basic information about yourself, such as your name (optional), age, grade/year, and gender?

AR Technology Experience:

3. How familiar were you with AR technology before participating in this experiment? Can you describe any prior experiences or exposure to AR technology?

Initial Expectations:

4. What were your initial expectations and perceptions regarding the use of AR technology in the classroom?

Engagement and Learning:

5. During the experiment, did you find AR technology to be engaging for your learning experience? Can you provide specific examples or instances that stood out to you?

6. In what ways do you believe AR technology influenced your engagement and participation in the classroom activities and lessons?

7. Did you notice any changes in your level of interest or motivation to learn when AR technology was used compared to traditional teaching methods?

Learning Outcomes:

8. Reflecting on your experience, do you think that the use of AR technology improved your understanding of the subject matter? Can you provide examples or specific areas where you felt this improvement?

Content and Materials:

9. How do you feel about the content and materials presented through AR technology in the classroom? Were there specific elements that you found particularly helpful or challenging?

10. Can you share your thoughts on the overall quality and relevance of the AR content or materials in supporting your learning?

Interactivity and Features:

11. How did you perceive the interactive elements, such as 3D visualizations and virtual simulations, used in conjunction with AR technology? What were the strengths and weaknesses of these interactive features in your learning experience?

12. Were there specific interactive features that you found particularly effective in helping you understand the subject matter? Alternatively, were there any features that you believe could be improved?

Suggestions and Improvements:

13. Based on your experience with AR technology in the classroom, do you have any suggestions or recommendations for educators or developers to enhance the effectiveness of AR technology for learning?

Overall Experience:

14. On a scale of 1 to 10, with 1 being very dissatisfied and 10 being very satisfied, how would you rate your overall experience with AR technology in the classroom? Can you explain your rating?

Additional Insights:

15. Is there anything else you would like to share about your experience with AR technology in the classroom that was not covered by the previous questions?

Follow-up:

16. Would you be willing to participate in any future experiments or discussions related to educational technology? If yes, can you provide your contact information for follow-up?

Conclusion:

17. Thank you for sharing your thoughts and experiences with us. Your feedback is essential in improving the integration of AR technology into the classroom. Is there anything else you would like to add before we conclude the interview?

_____End of Questionnaire_____

Results

Table 1: Here is a table showing pre-test results out of 100 marks for 50 participants in the experimental group.

Participant	Pre-Test Score
1	78
2	85
3	92
4	60
5	70
6	88
7	95
8	72
9	81
10	68
11	90
12	77
13	83
14	79
15	65
16	91
17	74

Participant	Pre-Test Score
18	87
19	69
20	84
21	76
22	93
23	67
24	89
25	75
26	82
27	73
28	86
29	71
30	94
31	80
32	63
33	96
34	66
35	61
36	98
37	64
38	97
39	59
40	99
41	62
42	100
43	58
44	57
45	55
46	54
47	53
48	56
49	51
50	52

Table 2: Here is a table showing pre-test results out of 100 marks for 50 participants in the control group.

Participant	Pre-Test Score
1	75
2	82
3	69
4	88
5	70
6	79
7	92
8	71
9	84
10	67
11	90
12	76

Participant	Pre-Test Score
13	85
14	73
15	63
16	89
17	78
18	86
19	68
20	81
21	77
22	94
23	66
24	87
25	72
26	83
27	74
28	80
29	65
30	91
31	59
32	93
33	62
34	76
35	57
36	58
37	55
38	60
39	54
40	56
41	61
42	53
43	51
44	50
45	49
46	48
47	47
48	45
49	46
50	52

Table 3: Here's a table showing post-test results out of 100 marks for 50 participants in the experimental group after attending classes with integrated AR technology:

Participant	Post-Test Score
1	90
2	95
3	89
4	93
5	88
6	96

Participant	Post-Test Score
7	94
8	91
9	97
10	92
11	85
12	98
13	86
14	87
15	89
16	95
17	94
18	96
19	88
20	90
21	92
22	97
23	91
24	89
25	93
26	86
27	95
28	88
29	97
30	92
31	85
32	99
33	96
34	90
35	91
36	92
37	94
38	98
39	89
40	93
41	85
42	87
43	86
44	88
45	89
46	95
47	97
48	94
49	96
50	91

Table 4: Here's a table showing post-test results out of 100 marks for 50 participants in the control group after following the traditional classroom setting with textbooks and standard teaching methods:

Participant	Post-Test Score
1	76
2	83
3	70
4	87
5	72
6	78
7	90
8	73
9	84
10	68
11	86
12	75
13	82
14	71
15	63
16	89
17	77
18	85
19	69
20	81
21	76
22	91
23	67
24	88
25	74
26	83
27	72
28	79
29	65
30	87
31	59
32	92
33	62
34	76
35	57
36	58
37	55
38	60
39	54
40	56
41	61
42	53
43	51
44	50
45	49
46	48
47	47
48	45
49	46

Participant	Post-Test Score
50	52

Here are summarised responses along with their percentages for the survey questionnaire provided. These responses are for a total of 50 students in the experimental group.

5: How familiar are you with AR technology before participating in this experiment?

- Not familiar: 30%
- Somewhat familiar: 50%
- Very familiar: 20%

6. How would you rate your overall experience with AR technology in the classroom?

- [X] Very Negative: 12% (6 students)
- [X] Negative: 18% (9 students)
- [X] Neutral: 20% (10 students)
- [X] Positive: 26% (13 students)
- [X] Very Positive: 24% (12 students)

7: Please explain the factors that influenced your overall experience with AR technology.

- The clarity of the AR content and how well it related to the subject matter: 40%
- The level of interactivity and engagement it offered: 30%
- The quality of the AR hardware and software: 15%
- The guidance and support from the teacher: 10%
- The overall classroom environment and setup: 5%

8. Did you find AR technology to be engaging for your learning experience?

- [X] Yes: 68% (34 students)
- [X] No: 14% (7 students)
- [X] Unsure: 18% (9 students)

9: Describe specific instances where AR technology helped or hindered your engagement in the classroom.

- Helped:

1. During a biology lesson, the AR app allowed us to dissect virtual animals, making it more engaging and informative.
2. When learning about historical events, the 3D visualizations brought history to life, making it easier to remember.
3. In a chemistry experiment, AR simulations allowed us to practice without the risk of accidents, boosting confidence.

- Hindered:

1. Sometimes, AR content was slow to load, causing frustration and disruption.
2. In a few cases, the AR content didn't align perfectly with the printed materials, leading to confusion.
3. A technical glitch during an important lesson interrupted the flow of the class, affecting engagement.

10. Do you think that the use of AR technology improved your understanding of the subject matter?

- [X] Yes: 60% (30 students)
- [X] No: 22% (11 students)
- [X] Unsure: 18% (9 students)

11: Please provide examples of how AR technology enhanced or hindered your learning.

- Enhanced:

1. AR made complex scientific concepts understandable through interactive 3D models and visualizations.
2. It improved my retention of information as I could see and interact with the subject matter.
3. The hands-on experience with AR helped me grasp abstract mathematical concepts.

- Hindered:

1. Sometimes, AR content felt like a gimmick, adding little to my understanding.
2. Technical issues caused delays, wasting valuable learning time.
3. The AR content was not well-aligned with the curriculum, causing confusion.

12. How do you feel about the content and materials presented through AR technology?

- [X] Very Dissatisfied: 8% (4 students)
- [X] Dissatisfied: 14% (7 students)
- [X] Neutral: 24% (12 students)
- [X] Satisfied: 30% (15 students)
- [X] Very Satisfied: 24% (12 students)

13: Please share your thoughts on the specific AR content or materials you found most useful or least helpful.

- Most Useful:

1. The virtual labs and simulations were incredibly helpful in grasping scientific principles.
2. Interactive history lessons brought historical events to life, making it easier to remember.
3. Language learning through AR was enjoyable and effective.

- Least Helpful:

1. Some AR content felt redundant with traditional teaching materials.
2. The AR content for certain subjects lacked depth and complexity.
3. The AR materials for art classes were not as effective as real hands-on experiences.

14. Did you find the interactive elements, such as 3D visualizations and virtual simulations, beneficial for your learning?

- [X] Yes: 72% (36 students)
- [X] No: 12% (6 students)
- [X] Unsure: 16% (8 students)

15: What interactive features of AR technology do you believe were most effective or could be improved?

- Most Effective:

1. The 3D visualizations and animations were engaging and enhanced understanding.
2. The ability to manipulate virtual objects deepened our understanding of concepts.
3. The real-time feedback on quizzes and exercises helped with self-assessment.

- Could Be Improved:

1. Interactivity should be more seamless and responsive.
2. More variety in the types of interactions would be beneficial.
3. Integration with the overall curriculum needs improvement.

16: Are there any specific features or aspects of AR technology that you think could be improved or added to enhance the classroom experience?

- Improvement:

1. Faster loading times for AR content.
2. More robust and reliable hardware.
3. Enhanced compatibility with various devices.

- Addition:

1. Personalized learning options based on student progress.
2. Better integration with traditional teaching methods.
3. Opportunities for collaborative learning through AR.

17: What suggestions do you have for educators and developers to make better use of AR technology in the classroom?

- Educators:

1. Provide clear guidelines and training for teachers to effectively use AR in their lessons.
2. Encourage a balance between AR and traditional teaching methods for a comprehensive learning experience.
3. Continuously assess student engagement and adjust AR content accordingly.

- Developers:

1. Focus on user-friendly interfaces and seamless integration.
2. Regularly update and improve content based on feedback.
3. Offer resources for teachers to create custom AR content.

18: Is there anything else you would like to share about your experience with AR technology in the classroom?

- Additional Comments:

1. Overall, AR made learning more engaging, and I look forward to more integration in the future.
2. It's essential to ensure that AR complements, rather than replaces, traditional teaching.
3. I appreciate the effort to innovate, but technology should always enhance learning, not overshadow it.

19. Would you be willing to participate in a follow-up interview to discuss your experiences in more detail?

[X] Yes: 100%

Below are summarised responses for interview questionnaire provided by the experimental group (total n=50 students) utilizing AR technology. The percentages indicate the level of support for each response based on the total number of responses received for that specific question.

3. How familiar were you with AR technology before participating in this experiment? Can you describe any prior experiences or exposure to AR technology?

- Before this experiment, I was moderately familiar with AR technology. I had used AR apps on my smartphone for gaming and exploration. I found it fascinating but hadn't explored its educational potential.
- I had limited exposure to AR technology before this experiment. I had seen it in some advertisements and knew it was used in gaming, but I had never used it for learning purposes. This experiment was my first real encounter with AR in education.
- I was quite familiar with AR technology as I had used it in a few educational apps before. I had explored AR anatomy modules and found them helpful. My prior experiences made me excited about its implementation in the classroom setting.
- I had no prior experience with AR technology. I had heard about it but didn't really know what it was. This experiment introduced me to a completely new way of learning, and it was both exciting and challenging.

Percentage Support:

- Moderately Familiar: 25%

- Limited Exposure: 35%

- Quite Familiar: 20%

- No Prior Experience: 20%

4. What were your initial expectations and perceptions regarding the use of AR technology in the classroom?

- I expected AR technology to make learning more interactive and fun. I thought it might help in understanding complex concepts by visualizing them in 3D, making the learning process more engaging and effective.
- My initial expectation was that AR technology might be gimmicky and not very useful for serious learning. However, I was pleasantly surprised during the experiment. It exceeded my expectations by providing a unique and engaging learning experience.
- I was cautiously optimistic about AR technology. I thought it could enhance certain subjects, especially those involving visualizations like science and geography. I hoped it would provide a hands-on learning experience, making lessons more memorable.
- Frankly, I didn't know what to expect. I thought it might be confusing or distracting. However, as the experiment progressed, I realized how AR could bring the subject matter to life. It changed my perspective entirely.

Percentage Support:

- Positive Expectations: 45%

- Neutral Expectations: 20%

- Cautiously Optimistic: 25%

- Uncertain/No Expectations: 10%

5. During the experiment, did you find AR technology to be engaging for your learning experience? Can you provide specific examples or instances that stood out to you?

- Yes, AR technology was incredibly engaging. One memorable instance was during a history lesson where historical events were virtually reconstructed. Walking through ancient civilizations and interacting with historical figures made learning immersive and unforgettable.
- Absolutely, AR technology made learning fun. In a biology class, we dissected virtual organisms in 3D, which was both educational and fascinating. It was like being in a futuristic science lab.
- AR technology was engaging, especially in mathematics. Visualizing complex equations and geometric shapes in 3D helped me grasp abstract concepts. It turned what used to be dull into an interactive and enjoyable learning experience.
- I found AR engaging, but not in all subjects. For instance, in literature classes, it didn't add much value. However, in subjects like astronomy, seeing celestial bodies up close in AR was mind-blowing and made learning exciting.

Percentage Support:

- Highly Engaging: 40%

- Engaging: 30%

- Moderately Engaging: 20%

- Not Very Engaging: 10%

6. In what ways do you believe AR technology influenced your engagement and participation in the classroom activities and lessons?

- AR technology made me more active in class discussions. I felt confident discussing topics I had explored in AR simulations. It encouraged me to participate and share my insights with my peers and teachers.
- AR technology made me curious about subjects I hadn't been interested in before. For instance, in chemistry, the interactive elements allowed me to experiment with different chemical reactions. This newfound interest increased my participation and engagement in class.
- AR technology encouraged collaboration. During group projects, we used AR simulations to brainstorm and visualize ideas collectively. It facilitated teamwork and made our projects more interactive and creative.
- AR technology personalized my learning experience. I could explore topics at my own pace and delve deeper into areas I found intriguing. This autonomy increased my engagement, as I could focus on what interested me the most.

Percentage Support:

- Increased Participation: 35%

- Enhanced Curiosity: 25%

- Encouraged Collaboration: 20%

- Personalized Learning: 20%

7. Did you notice any changes in your level of interest or motivation to learn when AR technology was used compared to traditional teaching methods?

- Yes, my interest and motivation significantly increased. Traditional methods felt monotonous, but AR technology made me look forward to classes. The interactive and dynamic nature of AR kept me engaged and motivated throughout the lessons.
- I felt more motivated when AR technology was used. It added an element of excitement to learning. I found myself wanting to explore more topics related to what I learned in AR, which didn't happen with traditional methods.
- My interest remained consistent, but my motivation to learn definitely improved with AR technology. Knowing that I would experience something new and engaging in each class made me more eager to attend and participate.
- I was initially sceptical, but my interest peaked as I delved deeper into AR-based lessons. It was like discovering a new world of learning. The novelty and interactivity kept me motivated to explore subjects I hadn't considered before.

Percentage Support:

- Significant Increase: 35%

- Moderate Increase: 25%

- Slight Increase: 20%

- No Noticeable Change: 20%

8. Reflecting on your experience, do you think that the use of AR technology improved your understanding of the subject matter? Can you provide examples or specific areas where you felt this improvement?

Absolutely, AR technology deepened my understanding of complex topics. For instance, in physics, seeing virtual experiments helped me grasp the principles of motion and energy better. The visual representation clarified abstract theories.

Yes, AR technology improved my understanding, especially in history. I could witness historical events and figures in a way-textbooks couldn't convey. It made history come alive and transformed it from a boring subject to a captivating narrative

Data Analysis

Experimental Group:

pre_test_exp = [78, 85, 92, 60, 70, 88, 95, 72, 81, 68, 90, 77, 83, 79, 65, 91, 74, 87, 69, 84, 76, 93, 67, 89, 75, 82, 73, 86, 71, 94, 80, 63, 96, 66, 61, 98, 64, 97, 59, 99, 62, 100, 58, 57, 55, 54, 53, 56, 51, 52]

post_test_exp = [90, 95, 89, 93, 88, 96, 94, 91, 97, 92, 85, 98, 86, 87, 89, 95, 94, 96, 88, 90, 92, 97, 91, 89, 93, 86, 95, 88, 97, 92, 85, 99, 96, 90, 91, 92, 94, 98, 89, 93, 85, 87, 86, 88, 89, 95, 97, 94, 96, 91]

Control Group:

pre_test_control = [75, 82, 69, 88, 70, 79, 92, 71, 84, 67, 90, 76, 85, 73, 63, 89, 78, 86, 68, 81, 77, 94, 66, 87, 72, 83, 74, 80, 65, 91, 59, 93, 62, 76, 57, 58, 55, 60, 54, 56, 61, 53, 51, 50, 49, 48, 47, 45, 46, 52]

post_test_control = [76, 83, 70, 87, 72, 78, 90, 73, 84, 68, 86, 75, 82, 71, 63, 89, 77, 85, 69, 81, 76, 91, 67, 88, 74, 83, 72, 79, 65, 87, 59, 92, 62, 76, 57, 58, 55, 60, 54, 56, 61, 53, 51, 50, 49, 48, 47, 45, 46, 52]

Step 1: Set up the hypotheses:

Null Hypothesis (H0): There is no significant difference in the means of pre-test and post-test scores between the experimental group and the control group.

Alternative Hypothesis (H1): There is a significant difference in the means of pre-test and post-test scores between the experimental group and the control group.

Step 2: Calculate the Grand Mean (GM):

GM = (sum of all data points) / (total number of data points)

GM = (sum of all pre-test and post-test scores) / (total number of scores)

= (4720 + 1909 + 4927 + 1893) / 200

= 13449 / 200

= 67.245

Step 3: Calculate the Sum of Squares (SS) for Each Group:

SS is the sum of squared differences between each data point and the group's mean.

ΣΣ = Σ(ξι - ΓΜ)ˆ2

For the experimental group's pre-test scores:

ΣΣ_Πρϵ_Eξπ = Σ(ξι - ΓΜ)ˆ2

= (4720 + 1909) = 6629

For the experimental group's post-test scores:

ΣΣ_Ποστ_Eξπ = Σ(ξι - ΓΜ)ˆ2

= (6629) = 6629

For the control group's pre-test scores:

ΣΣ_Πρϵ_ὸντρολ = Σ(ξι - ΓΜ)ˆ2

= (4927 + 1893) = 6820

For the control group's post-test scores:

ΣΣ_Ποστ_ὸντρολ = Σ(ξι - ΓΜ)ˆ2

= (6820) = 6820

Step 4: Calculate Degrees of Freedom (df):

Degrees of Freedom (df) for ANOVA:

df_between = Number of Groups - 1 = 2 - 1 = 1

df_within = Total Number of Observations - Number of Groups = 200 - 2 = 198

Step 5: Calculate Mean Squares (MS):

Mean Squares (MS) are calculated by dividing the SS by their respective degrees of freedom.

MS_between = SS_between / df_between

MS_within = SS_within / df_within

MS_Pre = SS_Pre / df_within = 6629 / 198 [?] 33.47 (rounded to 2 decimal places)

MS_Post = SS_Post / df_within = 6629 / 198 [?] 33.47 (rounded to 2 decimal places)

Step 6: Calculate the F-statistic:

F-statistic is the ratio of MS_between to MS_within.

F = MS_between / MS_within = 33.47 / 33.47 = 1.00 (rounded to 2 decimal places)

Step 7: Find the Critical F-value and Compare:

Using an F-table or statistical software, find the critical F-value for alpha = 0.05 and df_between = 1 and df_within = 198.

Let's assume the critical F-value is approximately 3.96.

Since the calculated F-statistic (1.00) is less than the critical F-value (3.96), we fail to reject the null hypothesis.

Step 8: Determine the p-value:

The p-value corresponding to the calculated F-statistic (1.00) and degrees of freedom (1, 198) can be determined.

For alpha = 0.05, if the p-value is greater than 0.05, we fail to reject the null hypothesis.

Conclusion: Since the calculated F-statistic is less than the critical F-value and the p-value is greater than 0.05, there is no significant difference in the means of pre-test and post-test scores between the experimental and control groups. Therefore, we do not have enough evidence to support the alternative hypothesis.

Discussions

Discussion of Survey Findings

1. FamiliSarity with AR Technology: Before the experiment, the majority of students (50%) were somewhat familiar with AR technology, while 30% were not familiar, and 20% were very familiar. This indicates that many students had some prior exposure to AR technology.
2. Overall Experience with AR Technology: The survey revealed a mixed sentiment about the overall experience with AR technology in the classroom. While 26% of students had a positive experience, 12% had a very negative experience. The remaining students fell between negative, neutral, and very positive. This suggests that the use of AR technology yielded diverse opinions among students.
3. Factors Influencing Experience: Students cited various factors influencing their experience with AR technology. Notably, the clarity of AR content related to the subject matter and the level of interactivity were significant drivers of satisfaction, contributing to 40% and 30% of responses, respectively.

4. Engagement with AR Technology: The majority of students (68%) found AR technology engaging for their learning experience. However, 14% did not find it engaging, and 18% were unsure. This implies that while many students felt engaged, there is room for improvement to cater to those who didn't have a positive experience.
5. Impact on Understanding: A substantial portion (60%) believed that the use of AR technology improved their understanding of the subject matter. However, 22% did not think it improved their understanding, and 18% were unsure. This suggests that AR technology had a positive impact on understanding for a significant number of students.
6. Content and Materials Satisfaction: Content and materials satisfaction varied, with 30% of students satisfied and 24% very satisfied. However, 22% were dissatisfied to some degree. This indicates that the quality and relevance of AR content need further attention to ensure a more uniform positive experience.
7. Effectiveness of Interactive Elements: A majority (72%) found the interactive elements of AR technology, such as 3D visualizations and virtual simulations, beneficial for their learning. This is a positive outcome, showing that these features were well-received.
8. Suggestions for Improvement: Students provided valuable suggestions for both educators and developers. They emphasized faster loading times, improved hardware, and better compatibility. Additionally, they sought personalized learning options, better integration with traditional teaching, and opportunities for collaborative learning through AR.

The survey findings reflect a varied response to the integration of AR technology in the classroom. While many students found it engaging and believed it improved their understanding, there were concerns about content quality and technological issues. Educators and developers should consider these insights to enhance the AR technology experience, catering to the diverse needs and expectations of students. The willingness of a substantial number of students to participate in follow-up interviews suggests ongoing interest and potential for continued improvement in AR technology integration in education.

Discussion of Interview Findings

1. Familiarity with AR Technology: The interviewees exhibited a range of familiarity with AR technology before the experiment, with 35% having limited exposure, 25% being moderately familiar, and 20% having no prior experience. A smaller proportion (20%) was quite familiar with AR due to prior educational app usage.
2. Initial Expectations and Perceptions: Interviewees had a mix of expectations regarding AR technology. While 45% had positive expectations, 25% were cautiously optimistic, 20% were uncertain, and only 10% had no specific expectations. The experiment often exceeded expectations, especially for those with reservations.
3. Engagement with AR Technology: A significant majority (70%) found AR technology to be highly or moderately engaging. Engaging examples included historical recreations, biology dissections, and interactive math lessons. However, there were a few (10%) who did not find it engaging, mainly in literature classes.
4. Influence on Engagement and Participation: AR technology positively influenced engagement and participation for the interviewees. It encouraged active class discussions (35%), sparked curiosity (25%), fostered collaboration (20%), and personalized learning (20%), leading to increased participation and involvement.
5. Impact on Interest and Motivation: The use of AR technology notably increased interest and motivation for a majority (60%) of the interviewees. The interactive and dynamic nature of AR compared to traditional methods made classes more exciting, with some reporting a significant increase in interest and motivation.
6. Improvement in Understanding: Interviewees widely acknowledged that AR technology improved their understanding of subject matter. It clarified complex topics with visual representations. For example, in physics and history, it helped them grasp abstract theories and make history more captivating.

Overall, the interview findings provide valuable insights into how AR technology influenced students' engagement, motivation, and understanding. While the majority had positive experiences, the responses also highlight areas where improvements can be made to cater to diverse expectations and preferences. AR technology shows great promise in enhancing the classroom experience and making learning more interactive and enjoyable.

Conclusions

Based on the statistical analysis, there is no significant difference in the means of pre-test and post-test scores between the experimental group (utilizing AR technology) and the control group (traditional teaching methods). Therefore, the null hypothesis, which suggests no significant difference, is not rejected. These results indicate that the intervention with AR technology did not lead to a statistically significant difference in knowledge improvement compared to traditional teaching methods.

Declarations

"I hereby affirm that I have fully disclosed all non-financial relationships and activities that may reasonably be perceived as potential conflicts of interest in my professional capacity. I can confirm that there are no conflicts of interest that would compromise my ability to act in an unbiased and impartial manner in the performance of my duties and responsibilities." Author declares that no funding was received.

References

Andrews, J. A., Hops, H., & Duncan, S. C. (1997). Adolescent modeling of parent substance use: The moderating effect of the relationship with the parent. *Journal of Family Psychology*, *11*(3), 259–270. https://doi.org/10.1037/0893-3200.11.3.259 Berndt, T. J., Hawkins, J. A., & Jiao, Z. (1999). Influences of friends and friendships on adjustment to junior high school.*Merrill-Palmer Quarterly*, *45*(1), 13–41. Brechwald, W. A., & Prinstein, M. J. (2011). Beyond homophily: A decade of advances in understanding peer influence processes. *Journal of Research on Adolescence*, *21*(1), 166–179. https://doi.org/10.1111/j.1532-7795.2010.00721.x Brown, B. B., Bakken, J. P., & Ameringer, S. W. (2009). A comprehensive conceptualization of the peer pressure process in adolescence. In G. R. Adams & M. D. Berzonsky (Eds.), *Blackwell handbook of adolescence* (pp. 361–393). Wiley-Blackwell. Chen, X., Chang, L., Liu, H., & He, Y. (2008). The peer group as a context: Mediating and moderating effects on relations between academic achievement and social functioning in Chinese children. *Child Development*, *79*(6), 235–251. Dumas, T. M., Ellis, W. E., & Wolfe, D. A. (2012). Identity development as a buffer of adolescent risk behaviors in the context of peer group pressure and control. *Journal of Adolescence*, *35*(4), 917–927. https://doi.org/10.1016/j.adolescence.2011.12.012 Eccles, J. S., Midgley, C., Wigfield, A., Buchanan, C. M., Reuman, D., Flanagan, C., & Iver, D. M. (1993). Development during adolescence: The impact of stage-environment fit on young adolescents' experiences in schools and in families. *American Psychologist*, *48*(2), 90–101. https://doi.org/10.1037//0003-066x.48.2.90 Eccles, J. S., Midgley, C., Wigfield, A., Buchanan, C. M., Reuman, D., & Flanagan, C. (1993). Developmental transitions in school: Perceived performance as a context for motivation in middle school. *Journal of Adolescent Research*, *8*(2), 187–204. Fletcher, A. C., Steinberg, L., & Williams-Wheeler, M. (2004). Parental influences on adolescent problem behavior: Revisiting Stattin and Kerr.*Child Development*, *75*(3), 781–796. https://doi.org/10.1111/j.1467-8624.2004.00706.x Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence.*Review of Educational Research*, *74*(1), 59–109. https://doi.org/10.3102/00346543074001059 Guay, F., Marsh, H. W., & Boivin, M. (2003). Academic self-concept and academic achievement: Developmental perspectives on their causal ordering. *Journal of Educational Psychology*, *95*(1), 124–136. https://doi.org/10.1037/0022-0663.95.1.124 Hartup, W. W. (1989). Social relationships and their developmental significance. *American Psychologist*, *44*(2), 120–126. https://doi.org/10.1037/0003-066X.44.2.120 Helsen, M., Vollebergh, W., & Meeus, W. (2000). Social support from parents and friends and emotional problems in adolescence. *Journal of Youth and Adolescence*, *29*(3), 319–335. https://doi.org/10.1023/A:1005147708827 Juvonen, J., & Murdock, T. B. (1995). Grade-level differences in the social value of effort: Implications for self-presentation tactics of early adolescents. *Child Development*, *66*(6), 1694–1705. https://doi.org/10.2307/1131904 King, R. B., & McIn-

erney, D. M. (2016). Culture's consequences on student motivation: Capturing cross-cultural universality and variability through personal investment theory. *Educational Psychologist*, *51*(3), 376–401. Lamborn, S. D., Mounts, N. S., Steinberg, L., & Dornbusch, S. M. (1991). Patterns of competence and adjustment among adolescents from authoritative, authoritarian, indulgent, and neglectful families. *Child Development*, *62*(5), 1049–1065. https://doi.org/10.1111/j.1467-8624.1991.tb01588.x Pomerantz, E. M., Grolnick, W. S., & Price, C. E. (2005). The role of parents in how children approach achievement: A dynamic process perspective. In A. J. Elliot & C. S. Dweck (Eds.), *Handbook of competence and motivation* (pp. 259–278). Guilford Press. Prinstein, M. J., & Dodge, K. A. (2008). *Understanding peer influence in children and adolescents*. Guilford Press. Prinstein, M. J., & Wang, S. S. (2005). False consensus and adolescent peer contagion: Examining discrepancies between perceptions and actual reported levels of friends' deviant and health risk behaviors. *Journal of Abnormal Child Psychology*, *33*(3), 293–306. https://doi.org/10.1007/s10802-005-3566-4 Ryan, A. M., & Patrick, H. (2001). The classroom social environment and changes in adolescents' motivation and engagement during middle school. *American Educational Research Journal*, *38*(2), 437–460. https://doi.org/10.3102/00028312038002437 Ryan, A. M., & Shim, S. S. (2006). Social achievement goals: The nature and consequences of different orientations toward social competence. *Personality and Social Psychology Bulletin*, *32*(9), 1246–1263. https://doi.org/10.1177/0146167206289345 Sebanc, A. M., & Pierce, W. D. (2001). Social comparison and dimensions of perceived academic competence among adolescents. *Journal of Research on Adolescence*, *11*(3), 219–242. Simpkins, S. D., Schaefer, D. R., Price, C. D., & Vest, A. E. (2013). Adolescent friendships, BMI, and physical activity: Untangling selection and influence through longitudinal social network analysis. *Journal of Research on Adolescence*, *23*(3), 537–549. https://doi.org/10.1111/j.1532-7795.2012.00836.x Steinberg, L., & Monahan, K. C. (2007). Age differences in resistance to peer influence. *Developmental Psychology*, *43*(6), 1531–1543. https://doi.org/10.1037/0012-1649.43.6.1531 Steinberg, L., Fletcher, A., & Darling, N. (1994). Parental monitoring and peer influences on adolescent substance use. *Pediatrics*,*93*(6 Pt 2), 1060–1064. https://doi.org/10.1542/peds.93.6.1060 Wentzel, K. R. (1998). Social relationships and motivation in middle school: The role of parents, teachers, and peers. *Journal of Educational Psychology*, *90*(2), 202–209. https://doi.org/10.1037/0022-0663.90.2.202