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Holograms in Education: Teachers' Insights on the Future of Interactive Learning

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Abstract

This study delivers important findings about holographic technology integration for education, which fill a gap in research within Saudi Arabian schools. The study aimed to assess how extensively holographic technology applications support educational interactions and learning results in Saudi Arabia schools. The research collected information from 420 middle school and secondary school teachers, including men and women from Al-Ahsa Governorate. The evaluation applied a three-item survey with a five-point Likert rating scale. The survey validation process included expert assessment and pilot examination of the instrument before use to measure teacher perceptions regarding hologram adoption in education. The collected data shows teachers possess average understanding of hologram application, although they encounter implementation obstacles from expensive equipment and insufficient manpower and technical know-how. The teaching staff acknowledges holographic technology offers potential advantages for upgrading student classroom engagement together with concept comprehension rates and learning drive. Teachers indicated their difficulties with both the curricular integration of holograms and the necessity for training resources dedicated to hologram use in education. The study reached its conclusion by identifying the necessity of resolving financial barriers alongside technical difficulties and trainer support to effectively use holograms in educational contexts. The recommendations involve building collaborative partnerships between public and private sectors in addition to delivering extensive training programs for teachers with education on hologram technology benefits. The established initiatives will lead to new learning spaces that combine innovation with immersion and comprehensive access to develop students capable of meeting today's world challenges.

Keywords: *Holograms; Teachers. Technology, School Systems, Educational, Challenges, Curriculum.*

Introduction

Generation Z, born between the mid-1990s and early 2010s, rely heavily on cellphones for communication, entertainment, and productivity. They are well-versed in and fond of brands, often choosing phones from reputable companies that align with their lifestyle. This generation is attracted to fashionable, cutting-edge, and socially conscious items, preferring smartphones with advanced features and technology. They favor devices equipped with high-quality cameras, fast processors, ample storage, and innovative technologies like AR and AI (Veybitha et al., 2021).

Holograms in Modern Classrooms

The hologram projection industry continues to evolve rapidly because it brings fundamental changes to educational systems and scientific applications primarily within STEM disciplines. Technology creates interactive three-dimensional images that help students better understand complex subjects, including molecular structures and engineering principles, because traditional

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two-dimensional methods lack sufficient effectiveness (Gangadi, 2024; Rakhmanov, 2023). Research evidence indicates that holograms function as educational tools that enable student participation while boosting knowledge retention rates among young learners (Suzanna, 2023; Astriani, 2024). Research on Hologram technology effectiveness in educational settings needs to expand through efficacy testing to prove its potential implementation in schools despite its technical hurdles (Gangadi, 2024; Ma & Lin, 2023). Technology will mature to become a fundamental educational tool, which will change how students interact with classroom material and perceive information in educational settings (Ma & Lin, 2023; Rakhmanov, 2023).

Hologram technology stands as a foundational educational technology that changes mixed reality teaching environments to provide next-generation learning experiences for the 21st-century student population (Aye et al., 2025; Gangadi, 2024). Standard medical images undergo processing in hologram displays to create realistic 3D anatomical models that enable real-time education and effective teaching through active learning practices (Babu & Bharanidharan, 2025). Hologram technology demonstrates its value in STEM education through student-friendly, complex visualizations that lead to better understanding and knowledge retention (Gangadi, 2024). The implementation of hologram media leads to better comprehension for students, as shown in studies that span diverse educational fields such as art, where multilingual holographic educational media helps students learning from different language backgrounds (Iriaji et al., 2024). Future studies must focus on validating Holograms educational applications and refining their deployment methods due to their wide-ranging educational value (Esquivel & Valverde 2024).

Educational institutions increasingly adopt holographic technologies because they offer an enhanced educational process that delivers immersive learning opportunities to advanced twenty-first-century students. The prediction among student teachers indicates holograms will play a major role as educational instruments in upcoming educational settings. The educational sector follows general immersive technology movements through virtual Reality (VR) and augmented reality (AR), which enable interactive learning outside traditional classroom settings (Khamis et al., 2024). According to Pitsikalis et al. (2024), the European Qualification Framework demonstrates how these technologies enhance educational engagement through motivation as well as critical thinking and creativity development. Enhanced education through immersive technologies faces problems regarding availability and instructor training, together with infrastructure requirements, before achieving equal access to students (Eden et al., 2024). The application potential of immersive technologies in the modern classroom stays strong because continuing research along with innovation developments ensure their successful deployment across elementary and higher education environments (Vashisht, 2024).

Research demonstrates that educational institutions should implement 3D hologram technology for enhancing student engagement and improving learning outcomes. Holograms enable students to visualize complex STEM materials effectively since they deliver immersive and interactive content that standard 2D methods cannot provide (Gangadi, 2024; Sertalp, 2024). Elementary schools using three-dimensional hologram technology demonstrated improved learning outcomes because students became more interested when interactive displays blended with their learning environment (Hakeem et al. 2024). Research conducted following COVID-19 confirmed that 3D hologram technologies provide a productive learning tool that successfully interacts with students who have endured learning fatigue in online settings (Carlian et al., 2024). The adoption of 3D holographic technology succeeds in maintaining student interest and creates a positive educational setting, which results in improved learning results, according to research

(Esquivel & Valverde, 2024; Sertalp, 2024).

Teacher Perceptions and the Need for Innovative Tools

Teachers' beliefs about technology integration and their educational outlook, along with their anticipations, directly shape the success of incorporating technology into educational systems. Teacher satisfaction towards administrative support combined with teaching infrastructure determines their success in facilitating effective technology integration. Indian teachers recognize satisfactory administrative support, yet Tanzanian teachers demonstrate dissatisfaction because of poor training and lacking IT infrastructure, which emphasizes the urgent requirement for systemic policy improvements and resource allocation (Benjamin & Dangwal, 2025). The usage of technology in mathematics education improves educational outcomes by creating more interactive instruction; however, it still generates obstacles from students' limited time and the necessary amount of technical equipment (Cadley, 2024). The acceptance levels of AI in the classroom by teachers show different responses according to their teaching experience; thus, training programs must address specific experience levels to develop positive AI-related attitudes (Prasetya et al., 2024). The potential of ICT engagement is known by Pakistani prospective teachers, yet they encounter constraints due to poor infrastructure and insufficient teacher training, thus requiring institutional support for capacity building (Jamil et al., 2024). Teachers in Jimma town face two crucial barriers, such as poor training and insufficient resources, which demonstrate the necessity for sustained educational development to improve educational technology adoption, according to Kebebe et al. (2024). Multiple studies demonstrate that teachers need systematic interventions for infrastructure along with training initiatives to achieve successful integration of technology across different educational environments.

The need for cutting-edge educational practices intensifies because traditional teaching methods demonstrate an inability to involve students properly and facilitate smooth information exchange (Carmical & Nadelson, 2025; Janardhanan & Charles, 2024). Studies show that combining PBL and digital technology integration enhances student interaction and educational success by improving math results for higher secondary students (Janardhanan & Charles, 2024; Humaira et al., 2024). Data shows that Professional Learning Communities (PLCs) aid educator adoption of innovative strategies, yet they face challenges from resource constraints and change resistance according to Carmical & Nadelson (2025). New educational communication practices provide power to teachers and students leading to boosted cooperative study spaces which advance social resistance and interdisciplinary learning opportunities (Yang, 2025). Educational methods based on innovation remain essential to develop adaptable learning settings which fulfill present-day educational requirements (Pirehbabi et al., 2024; Humaira et al., 2024).

Research Objectives

The study aimed to determine holograms integration within education to improve educational interaction and learning outcomes in Saudi Arabia.

Research Questions

This study was based on the following research questions:

RQ1. To what extent do teachers recognize and integrate holograms into the teaching and learning process?

RQ2. What are the implications of using holograms for the educational process in school systems?

RQ3. What challenges do teachers face in using holograms as part of their curriculum?

Literature Review

The Potential of Holographic Technology in Education

Educational experiences benefit significantly from holograms when used as an effective teaching instrument. 3D holographic technology operates as an effective educational instrument to develop learning environments where different student groups actively engage with visual content, according to Lee (2013). The review of Yoo et al. (2022) on educational holographic applications showed that students learn complex STEM topics better with holographic methods. The combination of Near Field Communication technology with hologram projection systems in early education programs receives evaluation from Astriani (2024). The merged technology makes visual learning possible for complex academic subjects among students of younger age brackets. 3D hologram technology offers ELEMENTARY SCHOOLS a sustainable scientific EDUCATION platform after COVID-19 because students continue to receive hybrid or remote instruction, according to Carlian et al. (2024). Through their research, Babu and Bharanidharan (2024) established that holographic displays allow students to have hands-on anatomy exploration through mixed reality platforms. Gangadi (2024) argues that holographic technology brings essential educational benefits to STEM instruction since it shows complicated systems to students with unprecedented levels of detail.

Teachers' Perceptions and Challenges

The promising applications of holograms face difficulties in implementation, according to various research works conducted among educational figures. The paper by Perifanou et al. (2022) investigates teacher perspectives regarding classroom AR integration while emphasizing both advantages and disadvantages. The research shows teachers understand the value of immersive technology tools yet experience challenges that mostly stem from their restricted technical skills and limited educational infrastructure, along with resistance to adopting new educational methods. Teachers provided information to Orhak and Çağıltay (2024) about the educational possibilities of virtual reality (VR) and holograms through interview procedures. The participants were positively receptive to technology because it strengthened student engagement, but they voiced worries about system accessibility and budget allocation, as well as requirements for training programs that would aid successful technology implementation. AlAli and Wardat (2024) provide detailed insights regarding why K-12 mathematics education faces issues when adding virtual reality and holographic tools. Investment challenges and curriculum inconsistency, along with technology dependence, pose obstacles to the proper implementation of education technologies in classrooms. The study results match the results presented by Francom (2020), who conducted a time-series survey to demonstrate how insufficient administrative backing and teacher development stood as ongoing obstacles to technology adoption.

Benefits for Teaching and Learning

Multiple academic studies indicate that holographic technology has a positive influence on student learning and instructional achievement. A 3D hologram-based medium for teaching coconut plants that Safitri and Djuniadi (2021) developed showed better student involvement and understanding than conventional educational techniques. Iriaji et al. (2024) achieved rapid art education concept comprehension through their introduction of multilingual hologram learning media systems, which students, together with instructors, accepted positively. Keselj et al. (2023) explore 3D holographic visualization technologies along with their practical applications in educational settings through their review. According to their research, holograms enable improved visualization and create an environment for collaboration because different users can engage with the material concurrently. According to Sertalp's (2024) research on hologram techniques in perspective modules, the technology shows promise for connecting theoretical information to practical usage.

Materials and Methods

Design

The study adopted a descriptive survey approach, which forms the foundation of the research. This approach aims to examine phenomena directly, providing both quantitative and qualitative descriptions of the results. Additionally, the methodology utilized in the study is explained.

Participants

The research included educational staff from the public-school sector across both genders situated in Al-Ahsa Governorate, which lies within the Eastern Province of Saudi Arabia. The questionnaire served as the main instrument to gather quantitative information for answering the research questions. Five hundred and ten teachers from the 2024-2025 academic period took part in this research. The researcher tested questionnaire reliability and validity by administering it to sixty teachers as part of a preliminary test phase. A research sample of 420 was composed of both male and female teachers chosen randomly from middle and secondary schools through Al-Ahsa Governorate. The questionnaire with clear directions was distributed to participants for their completion. The study received free voluntary participation from participants who maintained autonomy through ethical standards throughout the procedure. Improving survey responses involved providing the questionnaire in Arabic and additional foreign languages. The questionnaire was separated into two parts, with the first section requiring demographic data (refer to Table 1) that incorporated gender, age group, educational profile, and teacher experience, and the second part sought subject-specific responses. Research-backed measures and empirical studies supported the development of questionnaire items.

Table 1. Demographic Breakdown of study Participants

DEMOGRAPHIC VARIABLES		**THE SAMPLE**	**THE NUMBER**	**PERCENTAGE %**
GENDER	Male	420	206	49.05%
	Female		214	50.95%
AGE	Under 25	420	87	20.71%
	26-35		133	31.67%
	36-45		129	30.71%
	Over 45		71	16.90%
EDUCATIONAL QUALIFICATION	Bachelor's degree	420	311	74.05%
	Master's degree		21	5.00%
	PhD		17	4.05%
	Other		71	16.90%

TEACHING EXPERIENCE	Less than 5 years	420	129	30.71%
	5-10 years		127	30.24%
	11-15 years		123	29.29%
	More than 15 years		41	9.76%
SUBJECT TAUGHT	Arabic	420	72	17.14%
	English		59	14.05%
	Social Studies		85	20.24%
	Science		71	16.90%
	Mathematics		72	17.14%
	Other		59	14.05%

Figure 1. Illustrates Demographic Data Through Participant Counts and Percentages.

Instrument

The research examined how teachers perceive and use hologram technology for educational activities with their students. The research instrument consisted of two separate sections for the study. The initial section of the survey obtained demographics from teachers about their experience and knowledge of holographic technology and included an ethical consent form. The second section of the study investigated participant emotions regarding holographic technology coupled with their educational applications together with both positive and negative variables encountered in classroom implementation. The research included three structural elements that focused on hologram perception and teaching environment implementation, together with recognition of implementation barriers. The scale used each dimension with ten items using a five-point Likert scale that went from "Strongly Disagree" (1) to "Strongly Agree" (5) (see Appendix A). At the start of development, the survey included 35 statements distributed between the three measurement areas. An expert panel validated the statements, and the researchers refined them to 30 statements for better clarity and relevance, along with greater comprehensiveness. Experts conducted a review to make the statements both useful for obtaining important answers and to eliminate possible confusion during the survey process. The research team administered the questionnaire to 60 participants to check its consistency and ease of understanding through a pilot study. The questionnaire assessment relied on Pearson's correlation coefficient, which revealed strong to moderate correlations in its results. The first dimension showed correlations between 0.698 and 0.853; the second demonstrated 0.743 to 0.801 correlations, while the third measure demonstrated 0.711 to 0.843 correlations. The internal consistency between each dimension score and the overall score exhibited values from 0.754 to 0.774, which indicates adequate reliability. The researcher built the questionnaires through Google Drive tools. The researchers acquired necessary approval from Al-Ahsa Education Department before distributing questionnaires to teachers and later presented the questionnaires officially to secure authorization for distribution to teachers. The author conducted the questionnaire delivery and retrieval process directly with Al-Ahsa educational district middle and secondary school teachers. The data collected included 420 completed surveys from the 450 questionnaires sent out, for which 93.33% of the participants responded. The data collection methods proved exceptionally effective based on the high number of complete questionnaires. The data collection timeframe spans from November 18 through December 9, 2024.

Statistical Analysis

The researcher utilized IBM Statistical Package for the Social Sciences (SPSS) version 26 as their research analysis tool due to its established recognition in the field. The researcher used arithmetic means as well as standard deviation, along with percentages, while also applying Pearson's correlation coefficient and Cronbach's alpha coefficient for developing robust yet reliable outcomes. SPSS 26 served to boost the study's research validity because it has built a reputation for performing precise and efficient statistical evaluation. The study-maintained reliability through its adoption of a significance threshold at $p < 0.05$ to establish statistical significance in the results. The research method enhanced validity in the data as well as guaranteeing trustworthiness and rigorousness of research results.

Ethical Considerations

The research study received authorization from the Al-Ahsa Educational District to ensure compliance with ethical rules. The school principals afterward granted permission to the researcher to conduct research in their educational institutions. Each participant received detailed informed consent paperwork prior to the start of study, which stressed their free choice and the dedication to strict research ethics throughout the period. The research obtained ethical authorization from King Faisal University's Ethics Committee through the approval with reference number KFU-2024-MAY-ETHICS2114 to demonstrate strict adherence to research ethics in this study.

Results

Quantitative findings are discussed and interpreted in relation to the research questions.

Research Question 1. To what extent do teachers recognize and integrate holograms into the teaching and learning process?

Figure 2 illustrates teachers' knowledge about hologram usage together with their implementation within educational environments. A moderate level of potential hologram awareness was detected from teachers whose average score reached 3.12 (62.40%). Survey results demonstrate that teacher knowledge about hologram advantages varies between 54% and 68%.

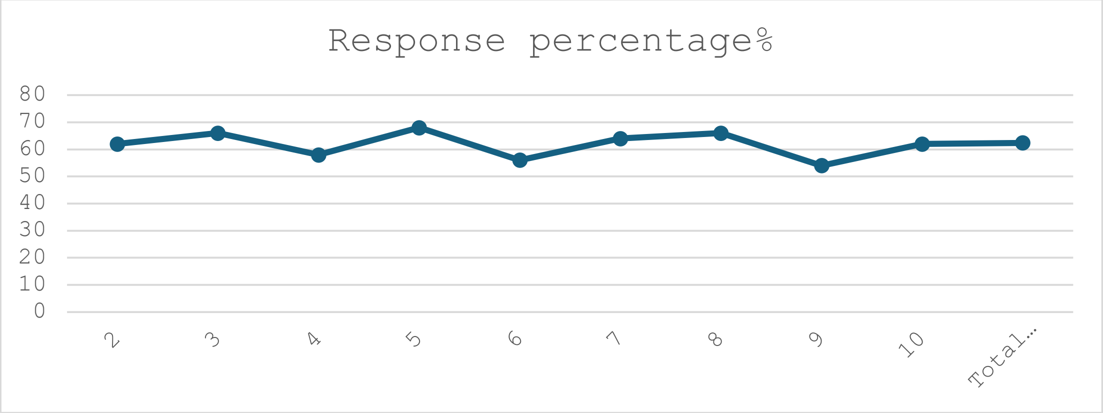

Figure 2. Response Rate to Hologram Awareness Statements

NO.	PHRASE	MEAN	STD. DEVIATION	RESPONSE PERCENTAGE%	CHI-SQUARE	SIG.
DIMENSION 1: AWARENESS AND INTEGRATION OF HOLOGRAMS IN TEACHING AND LEARNING						
1	I recognize the potential of holograms to enhance student engagement in the classroom.	3.2	0.8	64.00	12.34	0.015
2	I believe holograms can make learning more interactive and enjoyable for students.	3.1	0.9	62.00	11.89	0.018
3	I am aware of how holograms can be used to explain complex concepts effectively.	3.3	0.7	66.00	13.45	0.012
4	I actively seek opportunities to incorporate holograms into my teaching methods.	2.9	1.0	58.00	14.21	0.010
5	I think holograms are a valuable tool for delivering innovative educational content.	3.4	0.8	68.00	12.78	0.014
6	I feel confident in my ability to use holograms as part of my teaching strategies.	2.8	1.1	56.00	15.12	0.008
7	I understand the role of holograms	3.2	0.9	64.00	13.67	0.011

	in bridging gaps between theoretical and practical learning.					
8	I believe holograms can cater to diverse learning styles among students.	3.3	0.8	66.00	12.90	0.013
9	I regularly update myself on the latest advancements in hologram technology for education.	2.7	1.2	54.00	16.34	0.006
10	I consider holograms an essential component of modern educational tools.	3.1	0.9	62.00	13.23	0.012
	Total	3.12	0.91	62.40	**KMO. 0.82**	

Table 2. Teachers' Knowledge About Holograms in Educational Process

In table 2, educational staff members demonstrate moderate understanding regarding how holograms can enhance teaching methods as well as student learning practices. Teachers show some awareness that holographic technology has value, though their actual implementation remains constrained, with an average reaching 3.12. Accountable educators state their agreement regarding holograms potential for student engagement enhancement, with an average score of 3.2 points, and embrace holograms for improving educational quality and student enjoyment at 3.1 points. The participants displayed difficulty with hologram usage confidence and application practice as shown by the lower "I feel confident in my ability to use holograms" (mean = 2.8) and "I actively seek opportunities to incorporate holograms" (mean = 2.9) response scores. The standard deviation levels between 0.7 and 1.2 demonstrate varying teacher responses but also show differences in their teaching experience with holograms. The statistical significance of the documented findings is proven by chi-square values along with $p < 0.05$ indicator. The measured KMO of 0.82 confirms that the data obtained is suitable for analysis purposes. Results from the Bartlett test of sphericity reached statistical significance with P = 0.001.

Research Question 2. What are the implications of using holograms for the educational process in school systems?

Figure 3 shows how participants reacted to holograms educational influence. Participants showed a consistently strong positive perception, according to the mean values between 4.0 and 4.4. The positive received response to holograms educational benefits was demonstrated by an 80%–88% rate of agreement. The chi-square analysis demonstrates statistical significance at $p < 0.001$, which verifies the reliability of the obtained findings. Responses exhibited similar consistency throughout the study sample based on the reported standard deviations, which ranged between 0.6 and 0.8.

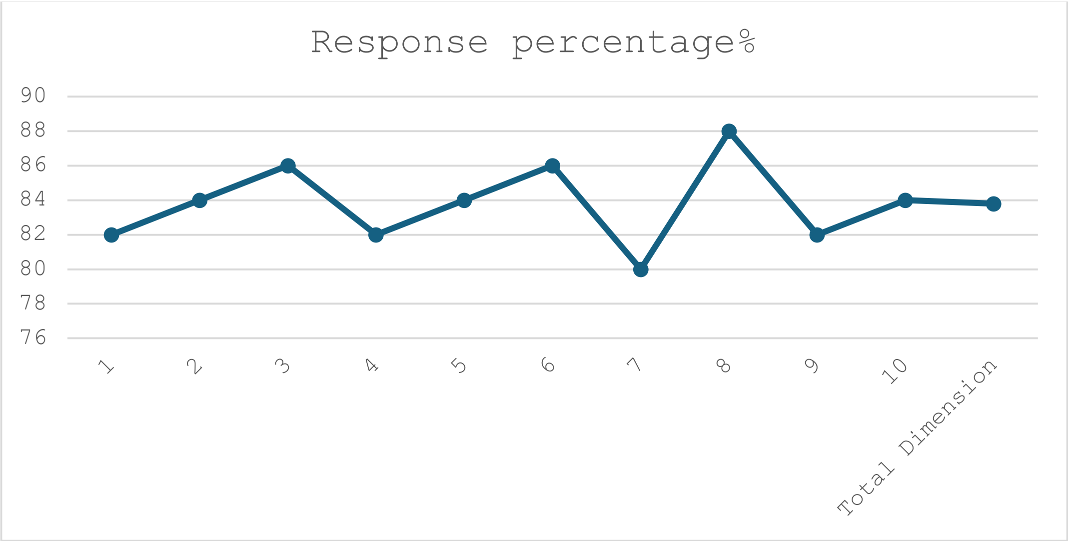

Figure 3. Response Rate to Impact of Using Holograms

NO.	PHRASE	MEAN	STD. DEVIATION	RESPONSE PERCENTAGE%	CHI-SQUARE	SIG.
DIMENSION 2: IMPACT OF USING HOLOGRAMS ON THE EDUCATIONAL PROCESS						
1	The use of holograms positively impacts students' motivation to learn.	4.1	0.7	82.00	18.45	0.001
2	Holograms help improve students' understanding of abstract or difficult topics.	4.2	0.6	84.00	19.23	0.001
3	Incorporating holograms enhances the overall quality of the learning experience.	4.3	0.7	86.00	20.12	0.001
4	Holograms contribute to better retention of knowledge among students.	4.1	0.8	82.00	18.78	0.002
5	The use of holograms fosters creativity and innovation in students.	4.2	0.7	84.00	19.56	0.001

6	Holograms promote active participation and collaboration in the classroom.	4.3	0.6	86.00	20.34	0.001
7	The integration of holograms reduces the reliance on traditional teaching methods.	4.0	0.8	80.00	17.89	0.002
8	Holograms provide a more immersive learning environment compared to conventional tools.	4.4	0.6	88.00	21.45	0.001
9	Students demonstrate improved academic performance when holograms are used.	4.1	0.7	82.00	18.67	0.001
10	Holograms help bridge the gap between theory and real-world applications.	4.2	0.7	84.00	19.34	0.001
	Total	4.19	0.71	83.80	**KMO. 0.85**	

Table 3. Mean Values with Standard Deviations Together with Response Percentages Using Chi-Square Methodology to Examine the Impact of Holographic Technologies on Educational Processes in Schools

In table 3. The research data demonstrates that teachers possess an extremely positive viewpoint about holographic technology's impact on education since their evaluation averaged 4.19. The positive perception of holograms comes from teacher interviews that validate their potential to create deep immersive learning environments (4.4) and improve learning quality (4.3). The teachers consistently agree about holograms' positive effects on motivation together with understanding and creativity since they show standard deviations ranging from 0.6 to 0.8 while presenting response rates between 80% and 88%. Research participants showed limited enthusiasm regarding holograms as a complete replacement for traditional teaching practices (mean = 4.0). The data reliability analysis consisting of a chi-square test ($p < 0.001$) and a KMO measure of 0.85 supports the research results. Results from the Bartlett test of sphericity reached statistical significance with $P = 0.001$. The discovery reveals both the necessity to invest in hologram technology development and teacher training programs for maximizing educational benefits from this technology.

Research Question 3. What challenges do teachers face in using holograms as part of their curriculum?

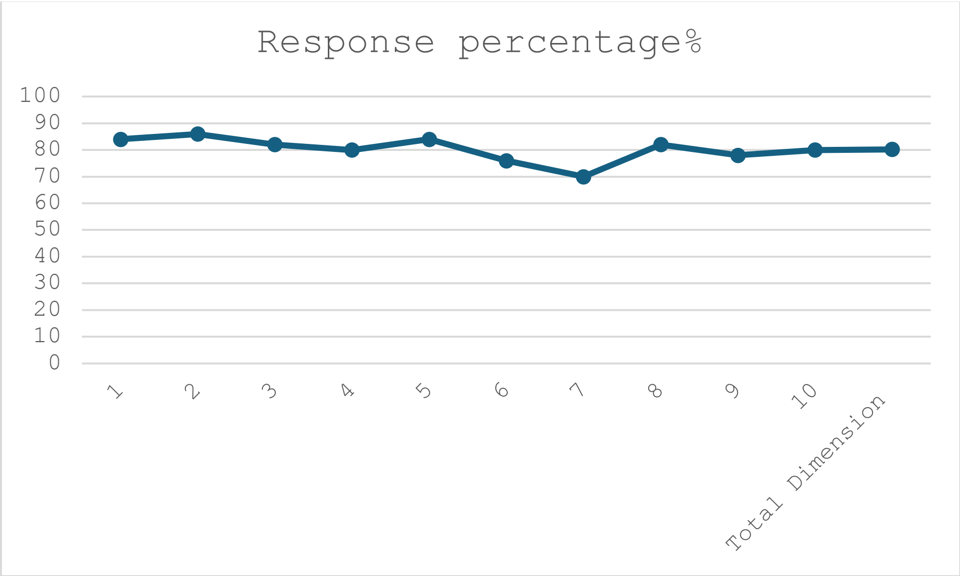

Figure 4. Teachers' Response to Hologram Adoption Challenges

NO.	PHRASE	MEAN	STD. DEVIATION	RESPONSE PERCENTAGE%	CHI-SQUARE	SIG.
DIMENSION 3: CHALLENGES FACED BY TEACHERS IN ADOPTING HOLOGRAMS						
1	I find it difficult to access hologram technology due to limited resources.	4.2	0.8	84.00	18.45	0.001
2	The cost of implementing holograms in education is a significant barrier.	4.3	0.7	86.00	19.23	0.001
3	I lack adequate training to effectively use holograms in my teaching.	4.1	0.8	82.00	17.89	0.002
4	There is insufficient technical support available for using holograms in schools.	4.0	0.9	80.00	16.78	0.003
5	Integrating holograms into existing curricula is challenging and time-consuming.	4.2	0.8	84.00	18.45	0.001
6	Many students face difficulties in understanding how to interact with holograms.	3.8	1.0	76.00	15.34	0.005
7	I worry that holograms may distract students from the intended learning objectives.	3.5	1.1	70.00	14.56	0.008

8	The complexity of hologram technology makes it hard to adopt in classrooms.	4.1	0.8	82.00	17.89	0.002
9	There is resistance from school administrators to invest in hologram technology.	3.9	0.9	78.00	16.23	0.004
10	I believe there is a lack of awareness about the benefits of holograms in education.	4.0	0.9	80.00	16.78	0.003
	Total	4.01	0.87	80.20	KMO. **0.85**	

Table 4. Mean Values and Standard Deviations Alongside Response Percentages and Chi-Square Analysis, Which Evaluates the Questionnaire Data Concerning Teaching Challenges with Holograms for Curriculum Delivery.

In Table 4. The results reveal significant challenges faced by teachers in adopting holograms, with an overall mean score of 4.01, indicating strong agreement on the barriers to implementation. The implementation cost of holograms in education stands as a major impediment, according to participants, with scores of 4.3, and their inability to access this technology because of resource limitations achieves a score of 4.2. Teachers face difficulties implementing holograms because of their insufficient knowledge of hologram technology, while also requiring appropriate training to benefit from these educational tools (4.1). The different standard deviation scores varying between 0.8 and 1.1 portray moderate teacher experience variation. The statistical reliability of these findings is demonstrated through chi-square values and significance level ($p < 0.05$), while the robustness of the data is validated by the KMO value of 0.85. These data points demonstrate that education needs financial investment along with technical support, as well as educator awareness programs, to make holographic technology implementation possible.

Discussion

The study uncovers a substantial difference between teachers recognizing holographic potential and their practical capability to employ this technology successfully. The research identifies major discrepancies between teachers' approval of hologram potential and their practical implementation ability. Education stands to gain from 3D holographic technology implementations despite a noticeable difference between educators who have identified its advantages and their limited experience integrating such solutions. The teaching staff recognizes that holograms play a vital role in educational content enhancement, according to their score of 33.4, but their implementation and understanding scores aof3.12 show limited practical knowledge of this technology (Lee, 2013; Yoo et al., 2022). Research indicates that hologram applications started in medical education and engineering, but their comprehensive educational outcomes are unstudied regarding age groups and academic fields (Yoo et al., 2022; Sertalp, 2024). Effective usage of holographic technology demands special training together with institutional backing since obstacles related to budget constraints and resource availability create implementation barriers (Safitri & Djuniadi, 2021; Jafari, 2023). Technology providers and educational institutions need to work together in developing a supportive learning space that maximizes holographic technology for teaching innovation (Lee, 2013 and Jafari, 2023).

The educational benefits of holograms remain unclear to teachers because they face multiple obstacles when attempting practical holographic implementations. Educators admit that holograms improve educational outcomes and boost student engagement but feel unconfident about implementing this technology because they operate at different levels of experience with the tool (Perifanou et al., 2022) (Lee, 2013; Yoo et al., 2022). According to research holographic technology shows promising potential yet too much expense and deficient digital skills and insufficient institutional backing block its effective classroom deployment (Sertalp, 2024, Orhak & Çağıltay, 2024). Successful incorporation of holograms in educational environments requires designed training programs combined with proper funding along with overcoming technical obstacles according to Perifanou et al., 2022 and Yoo et al., 2022.

Based on Table 4 teachers strongly agree about the key implementation barriers they face while adopting holographic technology. Education has multiple barriers to implementing holographic technology integration which research studies have consistently identified. Current studies support our findings as they establish cost restrictions alongside resource deficiencies as the leading impediments in adopting virtual reality technology and educational technology implementation (AlAli & Wardat, 2024; Škola et al., 2024). Educational challenges face further challenges because of incomplete teacher preparation, together with inadequate assistance for complex educational technology systems (Francom, 2020). The implementation of hologram technology requires professional training and simplified integration procedures due to its complicated nature (Lee, 2013). Research shows financial barriers need removal together with technical problems, and sustained awareness efforts will enable schools to optimize hologram utilization in education, according to Škola et al. (2024).

Hologram technology integration into education remains difficult because schools lack qualified teachers to handle this technology and because funding maintenance is limited, and technical support is insufficient. Research documents that holograms strengthen education through topic simplification for better student participation (Sertalp, 2024; Barkhaya & Halim, 2016). The budgetary requirements put a barrier in the way of adopting this technology because schools lack enough funding to purchase needed equipment along with training (Lee, 2013). To achieve maximum educational value from holograms it is crucial to develop specific professional development resources and streamline process integration according to Barkhaya and Halim (2016).

The successful implementation of holograms within educational environments needs proper training alongside enough financial support, while addressing current technical problems. Interactive 3D visuals from holographic technology result in better educational results because they enable students to understand difficult science, technology, engineering, and mathematics academic material better (Gangadi, 2024). The deployment of this system faces difficulties because researchers need to study its operations and develop adequate safeguards (Gangadi, 2024). Student learning success based on holograms results in engaged learners with improved understanding, but teaching staff must use innovative multimedia curriculum strategies to implement holographic educational objectives, according to Hakeem et al. (2024). Scientific investigations must examine multiple educational environments because current research does not provide data about different-age students or class subjects; thus, scientists require evidence about holographic applications across diverse learning settings (Yoo et al., 2022). Hologram success in education requires addressing the current proving issues that exist.

Holographic technology shows promise to speed up educational processes, according to the findings of Gangadi (2024) and Sertalp (2024), because students learn better with visual elements that remain more effective than traditional instructional approaches. The technology's complete implementation requires addressing multiple obstacles that involve controlled educational training programs, sufficient financial backing, and solutions to system limitations. For holograms to establish their educational value, students and teachers need additional scientific proof (Gangadi, 2024; Lee, 2013). According to Keselj et al. (2023), holographic applications display transformative qualities, particularly in geometry education, since interactive functions enhance educational value. Research implies that maintaining high-quality holographic technology implementation in different academic fields could redefine teaching practices, yet only after resolving its technical constraints.

Public-private partnerships offer Africa a solution to improve digital infrastructure and education policy technology inclusion through their support of sustainable development and inclusive growth (Jibrin et al., 2024). Research in higher education demonstrates holographic technology integration has the potential to improve educational results through its capability for virtual student interaction with enhanced presence in medical education along with engineering and other academic fields (Yoo et al., 2022). Implementing these technologies faces multiple barriers which involve ordinary implementation hurdles and financial restrictions and requires instruction and student training measures (Tkachenko, 2024). Modern educational technology implementations within institutions demonstrate their ability to boost the quality of education and student motivation and prepare them for workforce requirements (Tkachenko, 2024). The combination of innovation progress and public-private partnerships supported by full government backing makes it possible to achieve better educational results at educational institutions.

Conclusions

The study establishes vital insights about implementing holographic educational technology through its assessment of deployment difficulties and potential benefits. Educators in the surveys establish holograms as transformative educational assets that enhance teaching approaches while improving student involvement and leading to improved learning accomplishments. Educational institutions struggle to implement holographic technology due to insufficient financial backing and poor training programs. Educational institutions encounter current obstacles that reveal a theoretical discrepancy between the holographic technology advantages and their effective educational utility. A combination of public-private alliances and government financial help enables the elimination of financial hurdles along with architectural impediments. Administrative institutions that form partnerships with private organizations can find funding for new technology development and digital infrastructure improvement, so teachers gain access to modern educational resources, including holographic technologies. The education system requires holo-training for teachers to build proper abilities in making effective use of holographic technology in academic programs. The implementation strategy that combines technological support with professional development systems will maintain smooth progress while maximizing the educational worth of this technology.

Hologram education benefits education without neglecting present system obstacles. The implementation of hologram technology enhances active educational activities, which boost student interaction while encouraging innovation, together with preparing students for future technical abilities. Holographic technology programs, structured appropriately, collaborate with governing policies and institutional partnerships to create teaching changes that enable an inclusive learning system for future students. The educational potential of holograms requires financial and institutional support to evolve educational policies that resolve current problems. These implemented measures within educational facilities will introduce new educational models that improve student success and advance technological capabilities to achieve standardized learning outcomes.

Limitations and Future Research

Studying has some limitations. The analysis concentrates on Al-Ahsa within Eastern Province, Saudi Arabia, which decreases the universal reach of results across various educational and technological contexts within Saudi Arabia. The study demands corresponding research based on different geographic locations to verify its results validity across diverse educational contexts. Second, some participants mentioned technical problems, including a weak online connection and insufficient technological support, which potentially affected their evaluations about hologram system acceptability as well as its operational success. Future research needs to study technological solutions as well as support systems that will enable educators to resolve these encountered barriers. Third, the main participant group in this study consisted of educational staff since the research omitted students and school administrators. Such a restricted perspective limits the ability to properly comprehend all education-related consequences of holographic technology implementation. Future investigations must engage a wide range of educational participants to deliver a complete understanding of how holographic technology influences the entire educational system. Fourth, teachers face obstacles because holographic education tools are not yet extensively used; therefore, some educators might establish biased judgments because they need additional training and real-world practice. Long-term professional development must remain a priority since it will help teachers develop their competency and assurance with these innovative tools. Future studies need to increase participant scope to realize enhanced research possibilities along with systematic evaluation of hologram process impact since students and faculty encounter technical obstacles and infrastructure constraints.

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Appendix A:

S1: A survey on the reality and challenges of using holograms by teachers in schools

NO.	PHRASE	STRONGLY APPLIES	APPLIES	NEUTRAL	DOES NOT APPLY	STRONGLY NOT APPLICABLE
	Dimension 1: Awareness and Integration of Holograms in Teaching and Learning					
1.	I recognize the potential of holograms to enhance student engagement in the classroom.					
2.	I believe holograms can make learning more interactive and enjoyable for students.					
3.	I am aware of how holograms can be used to explain					

	complex concepts effectively.					
4.	I actively seek opportunities to incorporate holograms into my teaching methods.					
5.	I think holograms are a valuable tool for delivering innovative educational content.					
6.	I feel confident in my ability to use holograms as part of my teaching strategies.					
7.	I understand the role of holograms in bridging gaps between theoretical and practical learning.					
8.	I believe holograms can cater to diverse learning styles among students.					
9.	I regularly update					

	myself on the latest advancements in hologram technology for education.					
10.	I consider holograms an essential component of modern educational tools.					

Continue.

NO.	PHRASE	STRONGLY APPLIES	APPLIES	NEUTRAL	DOES NOT APPLY	STRONGLY NOT APPLICABLE
	Dimension 2: Impact of Using Holograms on the Educational Process					
11.	The use of holograms positively impacts students' motivation to learn.					
12.	Holograms help improve students' understanding of abstract or difficult topics.					
13.	Incorporating holograms enhances the overall quality of the learning experience.					

14.	Holograms contribute to better retention of knowledge among students.					
15.	The use of holograms fosters creativity and innovation in students.					
	Holograms promote active participation and collaboration in the classroom.					
16.	The integration of holograms reduces the reliance on traditional teaching methods.					
17.	Holograms provide a more immersive learning environment compared to conventional tools.					
18.	Students demonstrate improved academic performance when					

	holograms are used.					
19.	Holograms help bridge the gap between theory and real-world applications.					
20.	The use of holograms positively impacts students' motivation to learn.					

Continue.

NO.	PHRASE	STRONGLY APPLIES	APPLIES	NEUTRAL	DOES NOT APPLY	STRONGLY NOT APPLICABLE
	Dimension 3: Challenges Faced by Teachers in Adopting Holograms					
21.	I find it difficult to access hologram technology due to limited resources.					
22.	The cost of implementing holograms in education is a significant barrier.					
	I lack adequate training to effectively use					

	holograms in my teaching.					
23.	There is insufficient technical support available for using holograms in schools.					
24.	Integrating holograms into existing curricula is challenging and time-consuming.					
25.	Many students face difficulties in understanding how to interact with holograms.					
26.	I worry that holograms may distract students from the intended learning objectives.					
27.	The complexity of hologram technology makes it hard to adapt in classrooms.					
28.	There is resistance from school administrators to invest in hologram technology.					

29.	I believe there is a lack of awareness about the benefits of holograms in education.					
30.	I find it difficult to access hologram technology due to limited resources.					