



Humanities and Educational
Sciences Journal

ISSN: 2617-5908 (print)



مجلة العلوم التربوية
والدراسات الإنسانية

ISSN: 2709-0302 (online)

Augmented Reality in Early Childhood Science: Perceived Importance and Status Quo from Teachers' Perspectives^(*)

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*) Received: 18 /12/2025

*) Journal Website:

Accepted: 21/1/2026

<http://hesj.org/ojs/index.php/hesj/index>

الواقع المعزّز في تعليم العلوم بمرحلة الطفولة المبكرة: الأهمية المُدركة والواقع الراهن من منظور المعلمين

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الملخص

يُعدّ التعرض المبكر للمفاهيم العلمية الأساسية من خلال الوسائل التفاعلية أمرًا مفيدًا لأطفال مرحلة ما قبل المدرسة؛ فهو يُسهم في تنمية قدراتهم على التفكير العلمي والنقدي، وتعزيز إدراكهم المعرفي (epistemic cognition) في مراحل نموهم اللاحقة، ففي مرحلة ما قبل العمليات المبكرة، يتميز الأطفال باعتمادهم على الخبرات الحسية، ومعالجة الأشياء الملموسة من حولهم وتجريبها، وتعمل تقنية الواقع المعزّز (AR) على تقريب المفاهيم المجردة وصعبة التصور إلى مخيلة الطفل، وهذه الميزة تجعلها وسيلة تعليمية مثالية، للتوظيف داخل الفصول الدراسية، إلا أن استعداد المعلمين ورغبتهم في تبني هذه التقنية هو ما يحدد مدى نجاح توظيفها في الفصول الدراسية، ولقد هدفت الدراسة الحالية إلى استكشاف مدى الوعي بالفوائد الموثقة لهذه التقنية، واستطلاع واقع تطبيق تقنية الواقع المعزّز من وجهة نظر المعلمين، وقد استجاب 104 من المعلمين في مرحلة ما قبل المدرسة بمدينة الرياض بالمملكة العربية السعودية، لاستبانة تناولت بُعدين هما: الأهمية المدركة، والواقع المدرك لتوظيف تقنية الواقع المعزّز في البيئات التعليمية لمرحلة ما قبل المدرسة، ولقد أظهرت النتائج وجود اتفاق بدرجة مرتفعة بين المعلمين حول فائدة تقنية الواقع المعزّز في تعزيز عملية تعلم المفاهيم العلمية، وتحفيزها، وإضفاء المتعة عليها، إضافة إلى ذلك، فعلى الرغم من إبلاغهم عن بعض التردد تجاه استخدام الواقع المعزّز نظرًا لحدائته، إلا أنهم أفادوا أيضًا بوجود دافعية ورغبة لديهم لتعلم هذه التقنية، وتوصي الدراسة الحالية ببذل مزيد من الجهود لتدريب المعلمين على أدوات وبرمجيات الواقع المعزّز، بهدف زيادة كفاءتهم الذاتية (self-efficacy).
الكلمات المفتاحية: تقنية الواقع المعزّز، المفاهيم العلمية، الطفولة المبكرة، وجهة نظر المعلمين.

Augmented Reality in Early Childhood Science: Perceived Importance and Status Quo from Teachers' Perspectives

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Abstract

Early exposure to basic scientific concepts through interactive means is advantageous for preschoolers. It helps with their scientific and critical thinking abilities and epistemic cognition in their upcoming developmental stages. In the early preoperational stage, it is characteristic that they rely on sensory experiences, manipulate and experiment with tangible objects around them. Augmented reality (AR) technology brings abstract and hard-to-visualize concepts closer to the child's imagination. This advantage makes it an ideal teaching aid to be used in classrooms. However, the educators' readiness and willingness to embrace this technology determines the extent of the success of its usage in classrooms. The study explores the awareness of the reported benefits of the technology and the implementation realities of AR from the educator's perspective. 104 preschool educators from Riyadh, Kingdom of Saudi Arabia, responded to the survey on two dimensions, perceived importance and perceived status quo of AR utilization in preschool educational settings. As hypothesized, we found a strong agreement among preschool educators that AR is beneficial for enhancing, motivating, and bringing joy to learning scientific concepts. Additionally, even though they reported being hesitant toward AR due to its novelty, they also reported that they are motivated and willing to learn the technology. The current study suggests further efforts to train educators with AR tools and software to increase their self-efficacy.

Keywords: Augmented Reality (AR) Technology, Scientific Concepts, Early Childhood, Teachers' Perspective

Introduction:

The abstract nature of scientific phenomena makes comprehension difficult for a child in the early preoperational stage of development. Adaptive and interactive learning methods help the child visualize and experience these phenomena concretely. It is well recognized that the utilization of Augmented Reality (AR) benefits the understanding of children at various developmental stages in scientific and non-scientific domains (Aydođdu, 2022; Aydogdu & Kelpšiene, 2021; Garzón et al., 2019; Lampropoulos, 2024; Ompok, 2024; Oranç & Küntay, 2019; Perifanou et al., 2023; Syahidi et al., 2019; Topu et al., 2023). Because in early childhood, the child relies heavily on concrete and sensory experiences during learning, AR becomes an ideal candidate to enrich the child's learning process.

Understanding the basic scientific concepts in early childhood is crucial. It sets the stage for developing epistemic cognition, scientific belief, and argumentation in children (Lampropoulos, 2024). It paves the foundation for critical thinking and prevents misconceptions about natural phenomena. One of the prominent characteristics of this stage is the ease of perception and learning with tangible materials and means. It is thus quintessential to intervene in this stage by taking advantage of rapidly evolving technological advancements, such as AR, that cater to this characteristic by embedding virtual elements in reality (Alkhabra et al., 2023; Aydođdu, 2022; Bülbül & Özdiñç, 2022; Garzón et al., 2019; Ompok, 2024; Syahidi et al., 2019), adding an empirical value to the knowledge content. This aids in better understanding various scientific concepts by attracting attention and interest in addition to improving the consolidation of the learning content (Aydođdu, 2022; Aydogdu & Kelpšiene, 2021; Bülbül & Özdiñç, 2022; Yilmaz et al., 2017). It is a means of acquiring basic concepts effortlessly in the later stages of education by stimulating the child's interest, play, collaboration, and exploration. Recently, AR has been emerged as a powerful and innovative instrument in early childhood schooling and in developing scientific concepts. The capability of this technology to simplify difficult-to-understand and, thus, difficult-to-teach concepts is remarkable. Complex concepts like space, planets, and stars could be brought closer to the child. It enriches reality with digital information such as 3D structures and

animation, enhancing the experience of hearing, sight, and touch during learning (Alkhabra et al., 2023; Aydođdu, 2022; Dibrova, 2016; Feng et al., 2022; Orańç & Kuntay, 2019; Zhao et al., 2021).

Since teachers are critical stakeholders in the educational process, if not the central pillar and change-makers, knowing their perspective on the importance and the status quo of AR is essential in implementing this technology at a classroom level. The existence of a seemingly paradoxical situation between technological optimism and practical adoption barriers can be observed in the literature. On the one hand, there is a consensus among teachers of different levels about its benefits in classrooms also being aware of its practical difficulties (Garzón et al., 2019; Ompok, 2024; Perifanou et al., 2023). For instance, teachers believe that AR can facilitate interactive and experiential learning and can bring otherwise inaccessible content to the convenience of the classroom. Additionally, they believe that abstract and complex concepts can be visualized in 3D and interacted with, facilitating children's imagination and joy in learning (Aydogdu & Kelpšiene, 2021; Dibrova, 2016; Perifanou et al., 2023; Yilmaz et al., 2017; Zhao et al., 2021). On the other hand, we can also find teachers reluctant to deploy such novel technologies due to multiple reasons. The belief around the difficulty and lack of time for learning and preparing AR-based materials, their potential to distract students, and even to negatively affect their imagination (Perifanou et al., 2023), would shape teachers' attitudes toward embracing such methods. Gaining a deeper understanding of this becomes essential to propose recommendations.

Given the importance of AR in preschool science education, would this be the case with the teachers who teach basic scientific concepts to preschool children as well? The current study addresses this question by investigating the importance and status quo of the usage of AR from the perspective of preschool teachers. Even though educators perceived importance and status quo of the practical implementation of AR in education have been explored (Garzón et al., 2019), these in the context of kindergarten students' scientific concept learning have yet to be comprehensively understood. The current study aims to tackle such a gap in literature.

We formalized the research questions as follows,

1. From the teachers' perspective, what is the importance of AR technology utilization in acquiring scientific concepts for kindergarten children?
2. From the teachers' perspective, what is the status quo of AR technology utilization in teaching scientific concepts to kindergarten children?

We hypothesize that teachers highly agree that the operation of AR technology improves the comprehension of scientific concepts for kindergarten children, and they believe that the usage of augmented reality technology raises children's motivation for learning. Additionally, we hypothesize that preschool teachers need more courses and technical support to use augmented reality technology. To address these research questions, we employed a descriptive survey method from preschool educators in the Riyadh, Kingdom of Saudi Arabia.

Literature review:

Thinking beyond traditional methods becomes valuable to enhance preschoolers' scientific concept acquisition. One such extensively used tool, AR technology, combines reality with virtual elements in the visual field (Al-Husseini & Duaa, 2023). Even though it began to emerge in the late sixties, computational limitations and accessibility were significant barriers to its widespread implementation. With the advancing computational capability, it becomes increasingly feasible to bring AR into smartphones and other wearable objects (Al-Husseini & Duaa, 2023; Aydogdu & Kelpšiene, 2021; Dibrova, 2016; Lampropoulos, 2024; Lorusso et al., 2018; Syahidi et al., 2019; Ye & Sitthiworachart, 2021). In their study, Fatih Aydođdu (2021) compared two groups of preschoolers using traditional instructional methods vs. smartphone-based AR materials. The experimental group was presented with 3-dimensional models of 8 animals, their descendants, and their shelters, while the control group received the same concepts presented in a printed 2-dimensional form. The knowledge of concepts, attention, and motivational skills was monitored before and after the intervention. The experimental group acquired significantly higher concept knowledge than the control group, in addition to increased attention and motivational skills (Aydođdu, 2022). The results demonstrate that even through readily available tools like smartphones, we could implement AR and yield learning and motivational benefits for children.

Furthermore, Juan Garzón and colleagues (2019) conducted a systematic review of 61 research papers on the utilization of AR in classrooms. They reported the common advantages identified from these studies. The most reported was the improvement in learning and motivation. Factors like sensory engagement and improved memory formation were attributed as the drivers of this improvement. Additionally, the acquisition of hard-to-explain concepts, including scientific and abstract concepts, was reportedly improved by using AR technology. Remarkably, it also increased collaborative learning among students (Garzón et al., 2019). Some disadvantages reported were the complexity of the technology, lack of attention to instruction from students because of the increased cognitive demand, and the unwillingness of teachers to employ the methods (Garzón et al., 2019).

As a key stakeholder in education, it is equally necessary to examine educator awareness and attitudes related to using such technologies in the classroom. Educator knowledge of AR technology is crucial for its next step of use in classrooms (Ompok, 2024). Alanazy (2023) found TL teachers had a positive attitude toward using AR, but their findings noted limited use due to lack of school networks and lack of the opportunity to train teachers on its use (Alanazy, 2023). In a more modest demographic sample, Elyyan (2017) also found a weak to moderate knowledge of AR use in social studies teachers in both male and female classrooms (Elyyan, 2017). Likewise, Al-Enezi & Al-Failkawi (2018) observed a similar trend of moderate awareness of AR technologies among faculty members in institutions of higher education (Al-Enezi & Al-Failkawi, 2018).

Alzahrani (2025) conducted a systematic review to examine how preschool children engage with Information and Communication Technology (ICT) and augmented reality (AR) in the context of science learning, and to explore preschool teachers' attitudes toward the use of these technologies. The review analyzed 23 studies published between 2000–2024, selected using PRISMA guidelines and a CASP-inspired quality analysis tool. The participants across these studies were preschool children (aged 3–6) and their teachers. The review found that most teachers hold positive attitudes regarding technology's potential, though their actual classroom use is often low or limited to traditional support. For children,

collaboration with ICT and AR led to improved scientific concept acquisition and social interaction. A significant research gap was identified regarding teachers' specific perceptions of AR.

A qualitative study by Alalwan et al. (2020) aimed to identify the obstacles and prospects of utilizing Virtual Reality (VR) and Augmented Reality (AR) in teaching science from the perspective of primary school teachers in a developing country. Data were collected from 29 primary science teachers, recruited via purposeful and snowball sampling, using semi-structured interviews. Thematic content analysis revealed common challenges for both technologies, including a lack of teacher competency, imperfect instructional design, lack of time, and inadequate environmental resources. A specific barrier for AR was the "bring your own device" (BYOD) policy restriction. Despite these issues, teachers saw significant prospects for AR/VR in improving exploratory behavior and developing positive student attitudes.

Aydoğdu (2022) used a quasi-experimental, pretest-posttest control group design to examine the impact of an AR-based program on the inspiration, consideration, and conceptual skills of preschool children. The 26 participants, all aged 4–5, were divided into an experimental group (n=13) that used an AR application about animals and a control group (n=13) that used regular flashcards. The study employed three instruments: a motivation scale (filled out by teachers), an attention scale (filled out by mothers), and a researcher-created "Concept Evaluation Form." The AR-based program was identified to be significantly more effective than traditional methods, with the experimental group showing better increases in motivation, attention, and concept skills (a 30.1% increase in concept knowledge versus 18.9% for the control group).

To determine preschool teachers' opinions on using AR in science education, Ozdamli and Karagozlu (2018) conducted a qualitative study. The participants were 10 preschool teachers of 3-, 4-, and 5-year-old pupils. The method involved training the teachers, who then used the Augment mobile application and AR flashcards in their science lessons for eight weeks. Data was gathered via semi-structured interviews following the implementation and analyzed using Nvivo. The results showed that AR positively influenced the teaching process by improving student creativity

and capturing attention. However, teachers also identified negative aspects, such as the application's lack of audio features and its failure to assist in the growth of fine motor skills.

Arici et al. (2021) employed a qualitative case study design to reveal the opinions of secondary school students and science teachers regarding AR technology's impact on perceived learning, interest, attitude, and experience. The study involved 40 students (grades 5–8) and 10 science teachers, who used the SPACE 4D AR application for astronomy subjects during 12 hours of lessons over three weeks. Data was collected using separate semi-structured interview procedures for students and teachers. Students reported that AR concretizes abstract concepts, makes lessons more enjoyable, and prevents boredom. Teachers concurred, noting that AR increases attention, curiosity, and knowledge permanence. Key challenges identified were insufficient tablets and the high cost of applications.

A comparative study by Kerawalla et al. (2006) aimed to explore the potential of AR for teaching primary school science by analyzing teacher–child dialogue. The study involved 133 children (mean age 10) and their teachers, comparing sessions using an AR “virtual mirror” interface (ARToolkit) with traditional teaching methods like role-play. Data from video recordings and semi-structured teacher interviews were analyzed to compare the interactions. The findings surprisingly indicated that children in the AR sessions were less engaged and more passive than those in the traditional role-play sessions. While teachers praised AR's ability to “make it real,” they criticized the content's inflexibility, noting a need to pause or slow the animations to improve learning.

Delello (2014) administered an exploratory case study to investigate pre-service teachers' (PSTs) views of the usability of the Aurasma AR platform and its role in facilitating science learning. The 31 PSTs participating in the study were required to create science-based AR “auras,” integrate them into lesson plans, and teach those lessons in their field placements. The primary data source consisted of 31 self-reflection papers written by the PSTs after their teaching experience. Findings revealed that most PSTs (87%) found Aurasma easy to use after an initial learning period. They perceived AR as highly motivating for their students, who were “amazed” and “excited.” Identified challenges included a lack of time, resistance from some mentor

teachers, and poor technological infrastructure in schools (e.g., weak Wi-Fi, lack of devices).

A mixed-methods study by Rahmat et al. (2023) introduced AR technology to 32 Indonesian science teachers and determined their perspectives on its implementation. The methodology involved a 65-minute introductory program where teachers explored AR applications, followed by data collection via an online survey (assessing knowledge and interest) and semi-structured interviews (with six teachers). The study uncovered that teachers had extremely low prior knowledge of AR; 75% had never heard of it, and none had used it for teaching. After the brief exploration, teachers expressed high interest, viewing AR as a valuable tool for visualizing abstract concepts and increasing student motivation. They overwhelmingly indicated a need for further training.

Yilmaz (2016) created “Educational Magic Toys” (EMTs) that employed AR technology for preschool education and used a mixed-methods approach to evaluating them. Participants in the study encompassed 30 teachers and 33 children (aged 5–6 years). Data were collected using a survey for teachers (the survey included items based on the Technology Acceptance Model, TAM), video observation of the children (behavior analysis, educational play patterns, etc.), and a structured interview with the children about their cognitive attainment. While teachers and children both enjoyed the EMTs and teachers held a high positive attitude toward them, despite the engagement and interaction of the children (pointing, inspecting, turning, etc.), the results suggested low cognitive attainment by the children. As for cognitive attainment, children provided “appearance descriptions” (what they saw), but the descriptions did not include “extensive descriptions” (what they learned).

A comparative study by Yoon et al. (2017) aimed to determine if AR could improve student understanding of the challenging scientific notion of Bernoulli’s principle in a science museum setting. The 58 middle school participants were randomly assigned to a non-AR (control) group or an AR group using the “Bernoulli Blower” exhibit. Data were collected through pre/post-intervention surveys (containing multiple-choice and open-ended questions) and post-intervention interviews. The AR condition demonstrated significantly greater knowledge gains on the multiple-choice survey and in

the interviews. The AR visualization was effective because it made hidden information (like the interaction between slow- and fast-moving air) visible, helping students understand the counterintuitive science.

In conclusion, using AR is advantageous overall in teaching and learning scientific concepts to preschoolers. According to literature, generally preschool teachers have positive attitudes concerning its usage in the classroom while also acknowledging the practical difficulties in its implementation. The current study focuses explicitly on preschool teachers' perspectives on using AR to teach scientific concepts in the Riyadh, Kingdom of Saudi Arabia. In other words, Augmented reality (AR) emerges as a promising complement to traditional methods for preschool science learning, with studies showing gains in concept knowledge, attention, and motivation when AR is delivered via readily available devices like smartphones (Aydođdu, 2022; Al-Husseini & Duaa, 2023; Lampropoulos, 2024). A broad review likewise links AR to improved learning, memory, and collaboration—while noting risks of cognitive overload and technological complexity (Garzón et al., 2019).

Evidence across settings indicates AR helps concretize abstract or hard-to-see phenomena, though engagement does not always translate to deeper cognition (Yoon et al., 2017; Yilmaz, 2016; Kerawalla et al., 2006). Teachers generally hold positive attitudes yet report low adoption due to limited infrastructure, time, and training, and BYOD or design constraints (Alanazy, 2023; Elyyan, 2017; Al-Enezi & Al-Failkawi, 2018; Alalwan et al., 2020; Rahmat et al., 2023). Recent synthesis specific to early years underscores children's social and scientific gains alongside a clear gap in understanding teachers' AR perceptions (Alzahrani, 2025), justifying focused inquiry in Riyadh.

Despite growing evidence that AR can boost young children's motivation, attention, and concept learning, the teachers' perspective on the real, day-to-day use of AR for preschool scientific concepts remains underexamined—especially in Saudi Arabia. Prior work largely aggregates mixed age groups or subjects, reports general attitudes rather than classroom enactment, and seldom distinguishes perceived importance from the perceived status quo of use. Findings also conflict on whether AR's engagement yields deeper cognition, and few studies link teachers' self-

efficacy, training access, infrastructure/BYOD constraints, and instructional design capacity to actual implementation quality. Moreover, validated, early-years-specific measures and contextually grounded data from Riyadh preschools are scarce. This creates a gap for research that systematically compares teachers' valuation of AR with their lived implementation barriers and support needs in early science, clarifying when AR translates from enthusiasm to effective, cognitively productive practice.

Methodology:

To serve both study aims of estimating perceived importance of augmented reality (AR) for learning science concepts in early childhood and perceived reality of AR usage in the classroom, a cross-sectional descriptive survey design was used. This was a methodologically suitable design for the tension of quantifying the prevalence and central tendency of attitudes in a defined population, at one point of time, in a way that minimized the threats to internal validity of observational designs that are not useful for the present purposes. A self-administered online questionnaire with Likert five-point items provided uniform measurement of the two constructs, efficient access to the Riyadh educator population, and direct operationalization of the research questions through proportions endorsing agreement and mean agreement scores. This method also facilitated measurement of internal coherence (e.g., item-total relationships, internal consistency) and preparation of implications relevant to improving teacher practices, (e.g., training needs, resources), providing a clear and empirically justified connection between selected method design and the study's descriptive aims.

Population and Sample:

The participants in this study included all early-childhood educators employed in public and private preschools found in Riyadh (N = 5,685). A random sample of 104 teachers was drawn from this population and invited to complete a questionnaire in an online format; the completed questionnaires became the sample for the analysis. Eligibility to participate was restricted to in-service preschool teachers who were responsible for the instruction of early-years students, and the invitation was sent electronically through school methods to ensure participation across both sectors of public

and private preschools. The sampling method reflects the descriptive nature of the study in addition to the logistical challenges of gaining access across a city; still, the resulting sample accurately represents approximately 1.8% of the population. Therefore, it must be remembered that it is an estimate of teachers' perceptions from the participating sample.

Instrument:

The questionnaire gauged two dimensions. The perceived importance and the perceived status quo of AR usage in the learning of scientific concepts in early childhood education. The perceived importance dimension was employed through 7 statements around the advantages of AR technology in education. The perceived status quo dimension was employed through the agreement ratings for six statements on the implementation status quo, their preparedness, and their willingness to administer AR technology in early childhood education settings. The questionnaire was administered online due to its cost efficiency and convenience in accessing teachers. All items used a five-point Likert scale (1 = strongly disagree with 5 = strongly agree).

Validity and Reliability of the Instrument:

To establish the instrument's validity and reliability, content validity was first secured through expert arbitration: specialists in early childhood education reviewed the initial item pool, after which items were reworded or removed in line with their recommendations, yielding the final questionnaire. Evidence of internal-structure validity was then examined via item-total correlations, which were positive and statistically significant for both dimensions (perceived importance: $\bar{r} = .76$, $p < .001$; perceived status quo:

$\bar{r} = .61$, $p < .001$), indicating coherent convergence of items on their intended constructs. Reliability analyses further supported score consistency: Cronbach's alpha was .88 for the perceived-importance scale and .70 for the perceived-status quo scale, meeting conventional benchmarks for good and acceptable internal consistency, respectively, in descriptive and exploratory research contexts.

Table (1) shows the average item-total correlations. The reliability for each dimension was also estimated using Cronbach's alpha.

Table (1)

The total correlation of the items and Cronbach's alpha values of both dimensions.

Dimension	Item-total correlations	Cronbach's alpha (std)
Perceived importance of AR utilization in the classroom	0.76 ($p < 0.001$)	0.88
Perceived status quo of AR implementation in the classroom	0.61 ($p < 0.001$)	0.7

Ethical Consideration

The study followed institutional ethical standards: approval was obtained, participation was voluntary with embedded e-consent, and no identifying data were collected. Responses were de-identified, accessible only to the research team, and reported in aggregate to protect confidentiality. Participants were informed of the purpose, procedures, minimal consequences, and their choice to withdraw at any time; data will be retained by policy and then securely destroyed.

Procedures of the Research:

The research utilized a descriptive survey of early-childhood educators in Riyadh: A random sample ($n = 104$) completed an online five-point Likert questionnaire regarding perceived importance (7 items) and perceived status quo (6 items) of AR use. Content validity was established by expert review and minor revision; voluntary participation was anonymous with embedded e-consent. Data collection occurred in a predetermined timeframe with one reminder, followed by a complete and quality screen (single submissions, time checks). Data were scrutinized for item-total correlations, Cronbach's alpha (by dimension) and descriptive statistics (means, SDs) using standard statistical software.

Results and Discussion:

We set out with the objective of identifying the perceived importance and perceived status quo of AR utilization in teaching scientific concepts to kindergarten children from the teachers' perspectives. We employed the descriptive survey method to address the research questions. We found a generally strong agreement on the importance-related statements and an average awareness of the status quo of AR implementation.

From the teachers' perspective, what is the importance of augmented status quo technology utilization in acquiring scientific concepts for kindergarten children?

Table (2)

Items, mean subjective ratings, and standard deviations of the first dimension.

Item	Mean	Standard Deviation
1-Augmented reality technology helps simplify complex concepts that are difficult to communicate in early childhood.	4.43	0.86
2- Augmented reality technology can create a positive impact on the development of scientific concepts in early childhood by increasing knowledge.	4.38	0.86
3- Presenting scientific concepts to early childhood has become clearer and easier when using augmented reality technology.	4.43	0.75
4- Using augmented reality technology contributes to teaching scientific concepts, combining fun and learning.	4.54	0.77
5- Augmented reality technology helps to communicate scientific concepts that are difficult for children to access or present in a tangible way.	4.38	1.02
6- The benefit gained by learning through augmented reality technology becomes greater and more proven for the child than other learning methods.	4.38	0.92
7- Using augmented reality technology makes learning more exciting and interesting in early childhood.	4.54	0.80

To answer the first question, we calculated the arithmetic means and standard deviations for the item. As shown in Table (2), preschool teachers' perspective on the importance of using Augmented reality technology in classrooms is generally positive and stronger. This, the results, the teachers



believe that AR technology helps increase knowledge and consequently has a constructive impact on the acquisition of scientific concepts for kindergarten students. This finding is consistent with the consensus among a multitude of studies on how AR could have a beneficial impact on learning (Aydođdu, 2022; Garz3n et al., 2019; Lampropoulos, 2024; Ompok, 2024; Perifanou et al., 2023). Additionally, acknowledging the difficulty in explaining abstract concepts at this young age, they strongly agreed that it simplifies the content and increases the ease and clarity of understanding. Being one of the core features of AR technology, bringing concepts that are hard to imagine and visualize into easy-to-digest 3D and animated representations will potentially benefit preschool children in understanding scientific concepts. Given that the reliance on sensory experiences at this developmental stage is high, it is not surprising that teachers agree AR could potentially bridge the gap between inaccessible concepts by presenting them in a tangible form. Collectively, these results are in line with the previous studies (Garz3n et al., 2019; Perifanou et al., 2023). Teachers consider incorporating AR in classrooms more beneficial than traditional methods and firmly believe it increases student engagement and excitement about the concepts.

In summary, the hypothesis that teachers highly agree that the employment of augmented reality technology improves the comprehension of scientific concepts for kindergarten children and the hypothesis that they believe using augmented reality technology increases children's motivation for learning were supported by the results.

From the teachers' perspective, what is the status quo of augmented reality technology utilization in teaching scientific concepts to kindergarten children?

Table (3)
Items, mean subjective ratings, and standard deviations of the second dimension.

Item	Mean	Standard Deviation
Early childhood educators are currently using augmented reality technology.	3.38	1.46
Early childhood institutions provide the necessary equipment and tools for augmented reality technology.	3.21	1.41
How much do you support the employment of augmented reality technology for early childhood learning?	4.39	0.93
I am prepared as an early childhood teacher to learn how to use augmented reality technology.	4.31	1.03
I hesitate to use augmented reality technology because it is a new learning method and difficult for children to understand and comprehend.	2.92	1.45
Augmented reality technology contributes to making learning more exciting and interesting in early childhood.	4.65	0.71

To answer the second question, the arithmetic means was calculated for each item in the dimension (Table (2)). Across all the questions, more than half of the teachers (54%) believe that AR technology is actively used among preschool teachers. It shows their awareness concerning the current status of AR usage in classrooms, and its potential to motivate them to embrace the usage of it due to this awareness that their peers are actively utilizing it. Additionally, there is average agreement that the institutions are equipped with the tools to incorporate AR technology in early childhood institutions. Further, they strongly support the use of such tools in classrooms and are prepared and motivated to learn how to use AR. Notably, they believe that the novelty of the technology would make it difficult for them and the children to understand.

Combined, the results indicate a strong agreement on the advantages of integrating AR into classrooms, an average level of awareness of the implementation status, and a strong willingness to embrace the technology. It must be acknowledged that a considerable number of respondents don't

perceive the current status of its implementation as widespread and are not firmly convinced that it is easy to implement this novel technology. Despite the novelty and uncertainty related to practical difficulties in its implementation (Garzón et al., 2019), preschool teachers firmly believe that they can take part in it. They are strongly motivated and prepared to learn and implement, seemingly realizing the potential of AR technology in improving the scientific concept learning outcomes of preschoolers. Consistent with previous findings, our study also points towards the requirement for adequate resources and training programs to reduce novelty-related implementation difficulties (Garzón et al., 2019).

Discussion:

The findings indicate robust endorsement of AR's pedagogical value for early childhood science: teachers reported high agreement that AR simplifies complex ideas, clarifies presentation, and increases enjoyment and engagement (Table (2)). These perceptions are theoretically consonant with the predominance of sensorimotor and concrete reasoning in the preoperational stage and empirically aligned with studies documenting AR's effects on attention, motivation, and concept learning in young learners. In this sense, Riyadh teachers' views corroborate international evidence that AR can render otherwise invisible or abstract phenomena tangible through 3D visualization and animation, thereby supporting conceptual access and memory.

At the same time, the perceived status quo of implementation was moderate, with sizeable variance around current use and institutional provisioning (Table (3)). Teachers strongly supported future adoption and reported readiness to learn AR tools, yet hesitancy related to novelty and concerns about classroom manageability persisted. This pattern mirrors prior reviews that contrast high perceived usefulness with practical constraints—time, infrastructure, device policies, and instructional design capacity. The divergence between “importance” and “status quo” suggests that uptake is gated less by pedagogical skepticism than by ecological feasibility and teacher self-efficacy, highlighting the need to translate enthusiasm into actionable capacity.

These findings have direct implications for policy and professional learning. First, more targeted practice-proximal training, which consists of

micro-credentials, coached lesson planning, and exemplar repositories, is likely to yield more value than generic workshops because it directly engages teachers in building confidence and design abilities. Furthermore, enabling conditions at the school level, such as devices/connectivity that are reliable, technical support, and age-appropriate AR content collected for teachers, should be intentionally cultivated at the same time to mitigate cognitive and logistical load on teachers. Lastly, program leaders might want to prioritize AR use cases grounded in early-years outcomes such as observation, classification, and spatial reasoning while embedding formative assessment as guidelines to ensure students are thinking deeply, not just highly engaged for the sake of being engaged.

In terms of the Riyadh context, the pattern of importance-preference indicates a classic capacity-conditions gap: Configuration of devices/content and teachers' willingness to use AR outstrip the availability of and access to age-appropriate materials for students. The tight coupling of learning of science in early-years education to the class schedule and physical, tangible materials means any use of AR will either reduce friction, or be part and parcel of the daily curriculum, and can fit into how long lessons are currently. Limiting digital access could also be an issue; forcing some students to use personal phones or creating situations where connectivity is secured in some contexts, but not others could further marginalize access to learning. Thus, system-level provisioning and local curation of AR resources, mapped to kindergarten standards and language needs, are essential to transforming perceived value into everyday practice.

Conclusion:

Augmented reality technology is increasingly accepted and implemented by educators of various levels and domains. Given the reliance on tangible and interactive experiences in the early preoperational stage of development, it is necessary to complement their learning of abstract scientific concepts with means that cater to this need. It sets the stage for an enhanced understanding of more complex concepts in their later development stages. Augmented reality technology could complement this requirement of tangible means through simplified and 3-dimensional visualization and other sensory experiences. Teachers are an integral stakeholder in implementing AR in classrooms. The level of competence and willingness

to learn about this technology, and their general positive attitude towards this technology, are some essential aspects of its implementation. To identify the perceived importance and status quo of AR utilization among teachers in the Kingdom of Saudi Arabia, we conducted the current study. We identified substantial agreement among them on the advantages of augmented reality in aiding the learning process of kindergarten students. Their agreement was slightly above average on the perceived status quo measures and shows that more effort might be required to improve the challenges around implementing the technology.

Recommendations:

Based on a study of high perceived importance and moderate implementation, the following recommendations focus on capacity, content, and infrastructures needed to transform teacher excitement for AR into everyday effective classroom practice.

1. Develop a phased implementation plan that pairs infrastructure readiness (devices, connectivity, options for classroom displays) with just-in-time technical support.
2. Providing practice-proximal professional development (coached lesson design, model lessons, micro-credentialing) focused on early-years science outcomes and classroom management, with AR.
3. Curating a vetted repository of AR resources in Arabic and editable bilingual English-Arabic, aligned to the kindergarten science standards, with teacher guides and formative assessment prompts.
4. Developing simple school-based policies that reduce BYOD reliance (e.g. providing classroom sets of devices) and that protect instructional time (e.g., offline-capable apps, preloading content).
5. Reviewing implementation with light-touch indicators (teacher self-efficacy, frequency of use, lesson alignment, student engagement/understanding) for iterative purpose of improvement.

Suggestions for Future Research:

To strengthen the evidence base and inform scalable adoption, future studies should move beyond self-reports to examine causal effects, implementation mechanisms, and equity implications of AR in early childhood science.

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Tables:

Table (1)

The item-total correlation and Cronbach’s alpha values of both dimensions.

Dimension	Item-total correlations	Cronbach’s alpha (std)
Perceived importance of AR utilization in the classroom	0.76 (p<0.001)	0.88
Perceived reality of AR implementation in the classroom	0.61 (p<0.001)	0.7

Table (2)

Items, mean subjective ratings, and standard deviations of the first dimension.

Item	Mean	Standard Deviation
1-Augmented reality technology helps simplify complex concepts that are difficult to communicate in early childhood.	4.43	0.86
2- Augmented reality technology has a positive impact on the development of scientific concepts in early childhood by increasing knowledge.	4.38	0.86
3- Presenting scientific concepts to early childhood has become clearer and easier when using augmented reality technology.	4.43	0.75
4- Using augmented reality technology contributes to teaching scientific concepts, combining fun and learning.	4.54	0.77

5- Augmented reality technology helps to communicate scientific concepts that are difficult for children to access or present in a tangible way.	4.38	1.02
6- The benefit gained by learning through augmented reality technology becomes greater and more proven for the child than other learning methods.	4.38	0.92
7- Using augmented reality technology makes learning more exciting and interesting in early childhood.	4.54	0.80

Table (3)

Items, mean subjective ratings, and standard deviations of the second dimension.

Item	Mean	Standard Deviation
Early childhood educators are currently using augmented reality technology.	3.38	1.46
Early childhood institutions provide the necessary equipment and tools for augmented reality technology.	3.21	1.41
How much do you support the application of augmented reality technology for early childhood learning?	4.39	0.93
I am prepared as an early childhood teacher to learn how to use augmented reality technology.	4.31	1.03
I hesitate to use augmented reality technology because it is a new learning method and difficult for children to understand and comprehend.	2.92	1.45
Augmented reality technology contributes to making learning more exciting and interesting in early childhood.	4.65	0.71