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Assessing the Utilization Level of Metaverse in Teaching Mathematics at the Primary Level: Perspectives of Teachers and Supervisors of Gifted Students

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Abstract

The integration of metaverse technology within the educational domain is progressing swiftly, owing to its advanced technological features. This technology has the ability to captivate learners and empower teachers by offering unique learning opportunities and capabilities. Hence, the present study sought to identify the extent of Metaverse technology utilization in primary-level mathematics instruction, as perceived by both supervisors and teachers of Gifted Students. The study employed a descriptive survey method and utilized a questionnaire as the primary research tool. The study's results indicated that teachers of gifted students acknowledged and utilized Metaverse technology to a significant extent in the context of teaching mathematics at the primary level Perspectives of Supervisors and Teachers themselves. This suggests that Metaverse technology has been effectively integrated into their instructional practices, enabling them to provide enhanced learning experiences for their students. The results of the study indicate significant statistical differences in the perspectives of teachers and supervisors of Gifted Students regarding the utilization of Metaverse technology in primary-level mathematics instruction. These differences were particularly evident among individuals who received more than two courses. However, no statistically significant differences were found based on the teachers' experiences with Gifted Students.

Keywords *Metaverse technology; Primary Level; Teachers of Gifted Students; Teaching Mathematics.*

Introduction

The twenty-first century has witnessed the pervasive integration of technology across diverse domains, rendering it an indispensable requirement (Azizi & Mujari, 2022). Notably, education has been profoundly impacted by the utilization and dependence on information technology, both within and beyond the confines of the classroom. Furthermore, unforeseen circumstances such as the ongoing COVID-19 pandemic, conflicts, natural calamities, and inclement weather have compelled educators, parents, and students to leverage the benefits offered by assistive technology within the realm of education (Hussain & Ibrahim, 2022).

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The emergence of the metaverse can be attributed as a logical outcome of the remarkable advancements in digitization and communication experienced during the modern era. Primarily utilized within the realm of media, the metaverse has progressively extended its influence across various other domains and facets of daily life (Al-Sawy, 2022). Furthermore, the widespread adoption of metaverses within social networking platforms has significantly expanded, transitioning from a concept once deemed fictional to an undeniable reality (Al-Zuhairi, 2022).

In response to emergency situations such as the COVID-19 pandemic and the need for remote learning support, the education sector has embraced the utilization of the metaverse, leading to its widespread integration (Mystakidis, 2022). The metaverse technology encompasses various immersive elements such as virtual reality (VR), augmented reality (AR), mixed reality (MR), and 3D environments, along with real-time interaction and seamless integration with artificial intelligence (AI). This technology facilitates a shared experience among an unlimited number of users worldwide, providing a truly immersive environment that closely replicates real-world settings. It enables users to engage in authentic virtual communication within environments that closely resemble reality (Lee et al., 2021; Kiong, 2022).

The metaverse is a contemporary technology that enables users to interact and collaborate within a virtual environment, seamlessly integrating virtual reality, augmented reality, and three-dimensional spaces. This immersive platform not only facilitates practical engagement but also offers a delightful and pleasurable communication experience within lifelike settings, providing users with a sense of joy, allure, and satisfaction (Zhang et al., 2022).

Figure 1 below illustrates the representation of Metaverse technology.

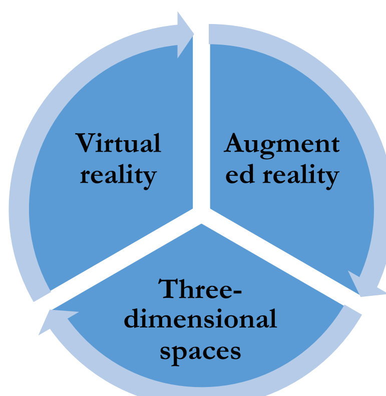

Figure 1 illustrates the representation of Metaverse technology

Numerous Metaverse platforms have been developed, such as Second Life, Open Simulator, Minecraft, Fortnite, Roblox, Sandbox, and Decentraland. These platforms have witnessed a steady increase in their user base, with membership numbers growing continuously (Rospigliosi, 2022). As virtual reality platforms become more user-friendly and interconnected, Metaverse platforms are poised for further advancements in diverse fields. Moreover, the potential for expanding their applications and adapting them to educational environments becomes even more feasible when virtual reality glasses and accessories are designed to offer enhanced comfort for extended usage.

In the realm of the metaverse, the development of hardware and software products specifically designed for educational environments holds significant importance. To ensure success in this endeavor, it is essential for educators, researchers, designers, and developers to collaborate and provide mutual guidance. Integrating new technological paradigms in education requires a comprehensive strategy that encompasses various aspects, as proposed by Sarıtaş (2015). This strategy should include curriculum development, teacher professional development, educational philosophy, data security, legal and political considerations, as well as the transformation of resources and infrastructure. Adopting such a holistic approach is crucial to effectively address the unique challenges that arise in metaverse-based education.

The researcher provides a formal definition of metaverse technology within the educational context as a communication medium facilitated through the Internet, enabling interaction between teachers and students. This virtual classroom environment utilizes three-dimensional representations where the teacher and students are visually represented. Within this immersive virtual space, the teacher delivers explanations and engages in discussions, fostering a sense of presence and awareness among the students. The metaverse technology offers a comprehensive range of educational capabilities and environmental perspectives, augmented by the integration of artificial intelligence applications. This immersive experience is realized through the utilization of augmented virtual reality glasses, which enable three-dimensional visualization.

The application of Metaverse technology in the educational realm is rapidly advancing, thanks to its cutting-edge features that captivate learners and empower educators to deliver exceptional learning opportunities. First, within the realm of classroom creation and setup, Metaverse technology offers teachers the ability to design a customized learning environment tailored to their specific subject matter. This technology further enables educators to select from a range of educational environments provided by existing models, catering to the interests and preferences of their students. One notable advantage of Metaverse technology is its seamless accessibility and communication, transcending barriers through the virtual world. This capability proves invaluable for overcoming the challenges associated with distance learning, as it facilitates direct interaction with students in a manner that emulates the natural educational environment. oreover, Metaverse technology plays a crucial role in surmounting obstacles posed by crises and emergencies that necessitate social distancing measures, such as the ongoing COVID-19 pandemic, epidemics, wars, and natural disasters. It offers a means to continue education remotely while maintaining a sense of connection and engagement among students (Hwang & Chien, 2022).

Secondly, in the domain of scientific content, Metaverse technology offers the opportunity to present scientific material in an engaging manner that captures students' attention and enhances their cognitive abilities. Metaverse technology also simplifies the presentation of complex and hazardous scientific materials and specimens, creating a safe environment that safeguards students from potential harm. Furthermore, Metaverse technology enables students to immerse themselves in a virtual world that closely mirrors the real world, showcasing natural landscapes such as mountains, plateaus, and seas. This immersive experience provides a technical environment where students can observe and explore subject matter in a realistic manner (Contreras et al., 2022).

Thirdly, within the realm of fostering motivation and enhancing the appeal of learning among students, Metaverse technology plays a significant role. Metaverse technology leverages augmented reality, employed by teachers in their interactions with students, which effectively captivates their interest and encourages their engagement with the educational process. This augmented reality component contributes to the students' acceptance and comprehension of the scientific material presented. Additionally, Metaverse technology facilitates a detailed exploration of complex and challenging subject matter. Through the utilization of high-quality graphics, images, and videos, the intricate components of the scientific material can be effectively explained and conveyed. Moreover, Metaverse technology capitalizes on the contemporary students' enthusiasm for modern technology and its applications, thereby attracting students to the lesson content. The virtual classroom environment fosters an ambiance of entertainment, further enhancing the students' level of engagement (Lin et al., 2022).

Mathematics is widely recognized as one of the most abstract subjects, often posing challenges for many students. The difficulty associated with this subject can be attributed to the abundance of symbols utilized within it, as well as the absence of tangible experiences that these symbols represent. Consequently, mathematical senses and their capacity to simplify mathematical concepts assume significant importance. As a result, the virtual mathematics laboratory has emerged as an indispensable educational tool that fosters and enhances learner motivation, aids in the retention of mathematical facts and concepts, and cultivates problem-solving skills. The American Council of Teachers of Mathematics advocates for the aforementioned approach (NCTM, 2000). Hence, it is imperative to employ more efficacious instructional tools to imbue mathematics education with meaning and equip students with a robust foundation, enabling them to perceive its significance and value. By doing so, mathematics can be transformed from an abstract subject into an accessible and enjoyable domain that resonates with the student's reality. Multiple studies have further substantiated the significance of Metaverse technology and virtual mathematics laboratory in mathematics education, specifically through the application of practical and simulated manual sensors and educational techniques. Metaverse technology is regarded as a microcosm of real life, bridging the gap between tangible experiences and abstract concepts (Al-Khathami & Al-Osaimi, 2022; Al-Ghanmi, 2022; Sarıtaş & Topraklıkoğlu, 2022; Zahrani, 2022).

The advent of Metaverse has made it feasible to utilize a simulated learning environment that allows learners to access tools and repeat experiences multiple times, at their convenience. Metaverse serves as a virtual learning environment, emulating realistic settings that enhance students' laboratory skills. It is accessible online and incorporates links and icons connected to activities, sensors, and virtual tools. Additionally, it leverages multimedia computer applications to assist students in developing scientific thinking skills as well as higher-order cognitive abilities such as analysis, synthesis, and evaluation. Through Metaverse, students can engage in immersive learning experiences, fostering their acquisition of essential skills and knowledge. Hence, the incorporation of the mathematics metaverse is an imperative educational requirement for attaining the objectives of mathematics instruction, particularly within primary education curricula that emphasize discovery-based learning. This approach involves teaching fundamental mathematical concepts through the utilization of artifacts and models as integral components of lesson delivery to students. By integrating the mathematics metaverse, learning quality and durability are enhanced, leaving a lasting impact on learners. This outcome stands as one of the foremost goals of mathematics education.

Several researchers (Al-Saeed, 2019; Hassan, 2019; Bujaily, 2019) have highlighted numerous advantages associated with the utilization of Mathematics Metaverse, including: Enhancing conceptual understanding: Mathematics Metaverse aids students in developing a deep conceptual understanding of mathematical concepts and fosters various mathematical thinking skills. Flexibility in learning: Students can engage in activities within the Mathematics Metaverse at their own pace and convenience, allowing for personalized and flexible learning experiences.

Professional development for teachers: Mathematics Metaverse equips mathematics teachers with effective teaching methods and tools, enabling them to seamlessly integrate theoretical explanations with practical applications of mathematical concepts. Innovative educational model: Mathematics Metaverse helps in creating a new educational model for the teaching of mathematics by leveraging immersive and interactive technologies. Real-life connections: The use of Mathematics Metaverse facilitates the establishment of connections between mathematical concepts and real-life situations, as well as their applications in various scientific fields. Overcoming resource limitations: Mathematics Metaverse compensates for the lack of physical laboratory resources by providing a wide range of virtual tools and simulations, thus overcoming the limitations imposed by a scarcity of physical equipment. By harnessing these advantages, Mathematics Metaverse offers a promising approach to enhance mathematics education and promote effective learning outcomes. The utilization of Metaverse provides an enriching platform for acquiring practical experience and bridging the gap between knowledge and its application. Furthermore, it facilitates the development of learners' cognitive and innovative processes.

Metaverse technology accomplishes several educational goals, particularly in the realm of mathematics, including promoting independent thinking: Metaverse enables students to exercise freedom of thought, encouraging them to think critically and creatively. Offering innovative and engaging resources: Metaverse provides a wide range of activities, resources, and educational tools that are innovative, enjoyable, and captivating for students. Creating a conducive environment for creativity and innovation: Metaverse fosters an educational environment that nurtures creativity and innovation, instilling self-confidence in students. Facilitating experiential learning: Metaverse supports students in gaining practical experience through the exploration and discovery of relationships and mathematical laws in a free and unrestricted manner. Developing fundamental mathematical skills: Metaverse facilitates the development of essential mathematical skills, guiding students from tangible experiences to semi-tangible experiences and ultimately to abstract understanding. Cultivating positive attitudes towards mathematics: Metaverse contributes to the cultivation of positive attitudes towards mathematics, making it more approachable, enjoyable, and relevant for students. The utilization of Metaverse provides an enriching platform for acquiring practical experience and bridging the gap between knowledge and its application. Furthermore, it facilitates the development of learners' cognitive and innovative processes (Abdel Hussein et al., 2020)

At the primary stage, several metaverse programs can be identified, including virtual hands, which are three-dimensional electronic models that enable students to engage their multiple senses while learning and teaching mathematics. These virtual hands offer various advantages, such as flexible accessibility and user-friendliness across different environments. Moreover, they facilitate students' development of independence in their mathematical learning process (Al-Ghanmi, 2022). In addition to simulating software for metaverse components, various tools can be utilized, including virtual hundred boards, virtual fraction templates, Deniz pieces, virtual counting pieces, Geoboards, and more. These tools provide interactive platforms within the metaverse that facilitate mathematical learning and exploration.

Engineering applications, such as GeoGebra, are specialized applications designed specifically for teaching mathematics. These applications can be installed on computers or tablets, and they are specifically developed to provide support in instructing mathematical concepts, generalizations, and skills. GeoGebra, in particular, offers a comprehensive set of tools and features that facilitate the effective teaching and learning of mathematics.

The effective utilization of metaverse technology in mathematics education requires mathematics teachers to possess several essential competencies, including: Evaluating educational software: Teachers should be adept at reviewing and assessing the suitability of educational software utilized in the teaching and learning process. Professional development: Teachers should engage in continuous professional development to enhance their proficiency in utilizing virtual laboratories as part of mathematics instruction. Participating in educational courses: Teachers should actively participate in educational courses that focus on teaching methodologies incorporating modern educational technologies. Emphasizing practical experience: Teachers should prioritize practical experience and seek opportunities to enrich it through workshops, meetings, and collaborative learning experiences. Computer and internet proficiency: Teachers should demonstrate proficiency in utilizing computers, internet networks, and educational media for teaching and assessment purposes.

Considering the significance of Metaverse technology encompassing virtual reality (VR), augmented reality (AR), mixed reality (MR), 3D environments, and artificial intelligence (AI) in mathematics education, as well as the researcher's expertise in the field of mathematics education and the observed shortcomings in its implementation and utilization by teachers, and building upon previous studies that highlight the positive impact of virtual laboratories on enhancing students' conceptual understanding, the research problem is defined as the assessment of the extent to which Metaverse technology is employed in mathematics instruction. Consequently, this study aims to investigate the degree of Metaverse technology utilization in the teaching of mathematics.

The present study aimed to address two primary research questions.

1. The first question is articulated as follows: What is the extent of teachers' of Gifted Students utilization of Metaverse technology in teaching mathematics at the primary level, as perceived by both supervisors and the teachers themselves?
2. The second research question is as follows: Are there statistically significant differences in the viewpoints of supervisors and teachers about teachers' of Gifted Students use of Metaverse technology in teaching mathematics at the primary level due to experience and training?

The emergence of new meta-educational models, as highlighted by Mystakidis (2022), opens up possibilities for immersive and blended learning experiences in online distance education and virtual campuses supported by the Metaverse. With online learning in the Metaverse, the physical presence in a traditional classroom becomes unnecessary. Avatars are believed to accurately convey body language and facial expressions, ensuring effective virtual participation. The mixed social reality of the Metaverse enables the implementation of blended active pedagogies, fostering deeper and long-lasting knowledge. Moreover, it promotes equal participation in education worldwide by providing a democratic environment free from geographical limitations. As the education sector embraces the Metaverse and its subcomponents, it is crucial to address the weakening of concepts such as race, gender, and physical disability within the Metaverse universe, as emphasized by Kuş (2021). It is worth noting that the challenges experienced in education during the Covid-19 pandemic, such as lack of focus, difficulty in following lessons, ineffective communication, limited class participation, and assessment issues, can potentially be overcome through the utilization of the Metaverse. Therefore, it becomes necessary to investigate the knowledge, attitudes, and awareness of teachers and education practitioners regarding the concept of the Metaverse.

The utilization of the metaverse is recognized as a highly significant and effective educational approach for attaining mathematics teaching objectives, particularly at the primary stage. This is due to its alignment with the developmental characteristics of primary stage students, according to Piaget's theory, which emphasizes their progression through the stage of sensory operations within their cognitive development. Consequently, the metaverse caters to the sensory perception needs of students at this stage, offering a flexible method that can be integrated with other teaching approaches such as discovery learning. Teachers can combine these methods to leverage their respective advantages and yield positive outcomes in mathematics education, provided that an appropriate educational environment is available. Additionally, effective planning and expertise in utilizing metaverse components are crucial for achieving the desired learning goals (Al-Mutairi & Rizk, 2022). In addition, facilitating educators in addressing their challenges and enhancing their proficiency in employing this technology, and aiding stakeholders in strategizing for the future to seamlessly incorporate this technology across all public educational initiatives. Apart from the abovementioned, the importance of this study lies in its potential to improve mathematics education, inform policies, and inspire further research and innovation in the field of educational technology.

Literature Review

Several studies (Park & Kim, 2022; Camilleri, 2023; Suzuki et al., 2020; Piumsomboon et al., 2017; Kanematsu et al., 2014) have provided suggestions for further advancing Metaverse technology in teaching environments. These recommendations can be summarized as follows: Creation of active learning environments: Emphasize the incorporation of experimental learning and gamification techniques to foster active engagement among students. Prioritization of storytelling: Place greater importance on narrative elements rather than solely focusing on visual effects, recognizing the power of storytelling in enhancing learning experiences. Integration of real-life elements: Avoid neglecting real-world elements, ensuring that the virtual environment closely mirrors and incorporates real-life scenarios and contexts. Utilization of scalable Metaverse technology and speech detection: Exploit the potential of scalable Metaverse technology, combined with speech detection capabilities, in conjunction with artificial intelligence, to enhance the overall educational experience. Support of pedagogy and content knowledge: Provide students with adequate support in terms of pedagogical approaches and content knowledge to optimize their learning outcomes within the Metaverse environment.

In a study conducted by Şahin (2016), the usability of the Second Life game in teaching social science was examined. An exemplary learning environment was created using the experiential learning model, involving pre-service teachers from various grade levels in the Department of Social Science Teaching. The study aimed to gather the experiences and opinions of the pre-service teachers within this environment. The findings revealed that social science education conducted through the Second Life platform enhanced the interest and motivation of pre-service teachers in the subject, facilitating tangible and enduring learning outcomes. Additionally, it was observed that the use of Second Life in teaching helped break the monotony of traditional lessons and elevated the self-efficacy levels of pre-service teachers.

The comprehensive review study conducted by Saritas & Topraklikoglu (2022) analyzed various research papers and reached consistent conclusions regarding the advantageous aspects of utilizing Metaverse technology in educational settings. The identified benefits include: Creation of a participatory and sustainable learning environment: Metaverse enables the establishment of an interactive and collaborative learning environment where learners actively engage in the educational process. Maximization of learning process efficiency: Metaverse technology has the potential to enhance the efficiency of the learning process, promoting effective knowledge acquisition and retention. Facilitation of diverse learning methods: Metaverse supports the implementation of various learning approaches, including synchronous and asynchronous learning, as well as innovative methods such as flipped classrooms and cooperative learning. Promotion of fun learning, motivation, and cooperation: Metaverse can be leveraged to create enjoyable learning experiences, fostering student motivation and promoting collaboration among learners. Ensuring student attendance: By utilizing Metaverse, educational institutions can ensure student participation and attendance in virtual learning environments. Contribution to trust-building, awareness-raising, communication skills, interaction, product creation, and team management: Metaverse technology contributes to the development of essential skills and processes such as trust-building, raising awareness, effective communication, interactive learning, collaborative product creation, and team management.

In their study, Durak & Karaoğlan Yılmaz (2019) sought to investigate the perspectives of 7th and 8th-grade students regarding the use of Augmented Reality (AR) applications in education. Through interviews conducted with 43 students, two prominent themes emerged in relation to the impact of AR on the learning process. The first theme highlighted the significance of AR in providing a fun learning environment, while the second theme emphasized its ability to make the learning process engaging and effective. One notable challenge identified by the students was the lack of smartphone ownership or access, which hindered their utilization of AR. Nonetheless, the students expressed their belief that incorporating AR into science, geometry, and mathematics lessons would be advantageous. Based on these findings, it was concluded that students perceive the use of AR as a beneficial tool for enhancing their learning experiences in various subject areas.

In the study conducted by Şimşek, Erbay, & Kirişçi (2019), a total of 34 fifth-grade students were selected as participants to investigate the impact of the Second Life virtual environment on the teaching of fractions at the fifth-grade level. The study followed a pre-test and post-test design, wherein the students' initial knowledge was assessed through a pre-test before the intervention. Subsequently, three sessions of Second Life courses were conducted in the computer laboratory with the students. Following the completion of the intervention, a final test was administered to evaluate the students' learning outcomes. The results revealed a significant increase in the scores obtained by the students on the final test, indicating a positive effect of the Second Life intervention on their academic success in the domain of fractions. Furthermore, the researchers concluded that the "Snow Dogs" activity within the Second Life environment captured students' attention more effectively compared to traditional teaching methods.

Özdemir & Özçakır (2019) conducted a study with the objective of investigating the mathematics achievement and attitude changes towards mathematics among students who learned the topic of fractions using Augmented Reality (AR) applications. The study involved 60 fifth-grade students, and it was observed that there was a significant difference in the students' achievements. The results indicated that the students' success scores increased, and their attitudes towards the mathematics course, taught with the integration of AR, exhibited positive changes. Consequently, it was concluded that the implementation of AR in mathematics instruction positively impacted both students' academic performance and their attitudes towards the subject.

Similarly, Altıok (2020) conducted a study aiming to examine the effects of mobile augmented reality-supported mathematics education on the academic achievements and perceptions of primary school students regarding the integrated educational process. The research involved 23 students at the third-grade level. The findings revealed a notable improvement in the students' comprehension and application of symmetry concepts. The study also highlighted the positive outcomes associated with mobile AR, such as the ability to visualize abstract concepts, enhancing the enjoyment of the lesson, and facilitating the learning process. However, some negative consequences were identified, including students' reservations about using technology and difficulties in accessing and operating the devices. Overall, the study concluded that the integration of AR in mathematics education facilitated student learning, resulted in improved academic performance, and had a positive and significant impact on the overall learning process.

Mutluoğlu & Erdoğan (2021) conducted a study to examine the impact of a virtual manipulative team, which they developed, on the mathematics achievement and attitudes towards geometry among sixth-grade students. The research employed a quasi-experimental design with a pre-test-post-test control group, which is a quantitative research methodology. The findings of the study indicated that the students who underwent the learning process with the virtual manipulative team achieved higher academic success in mathematics lessons compared to the control group. Furthermore, their attitude scores towards geometry also demonstrated an increase. These results suggest that the utilization of the virtual manipulative team had a positive effect on both the students' academic performance in mathematics and their attitudes towards geometry.

Boz & Özerbaş (2020) conducted a study to explore the perspectives of classroom teachers regarding the integration of technology in mathematics lessons. The research employed a mixed-method approach and included a sample of 125 classroom teachers. The findings of the study revealed that the majority of classroom teachers (84.2%) held a positive view towards the utilization of technology in mathematics teaching. Specifically, it was observed that 81% of primary school teachers expressed a positive stance regarding the incorporation of technology in mathematics education. These results indicate a favorable disposition among classroom teachers towards leveraging technology as a pedagogical tool in mathematics instruction.

According to the statements provided by classroom teachers, the use of interactive whiteboards in mathematics lessons offers several benefits, including the ability to visualize and grasp abstract concepts, ensuring equal opportunities for students, capturing attention, and promoting better retention of knowledge. Additionally, teachers have observed that the integration of technological tools and equipment in the classroom enhances students' interest and motivation towards the subject matter. The teachers have identified specific tools that they deem essential, namely the Internet, a computer, a video player, an interactive board, and a calculator. Furthermore, they have emphasized the importance of selecting and utilizing technological tools and equipment that align with the specific needs and requirements of each semester or instructional period in the mathematics course (Şeyma & Özdemir, 2022).

Numerous studies have substantiated the efficacy of virtual laboratories and their constituent programs in enhancing teaching competence, elevating achievement levels, improving thinking skills, sustaining the learning impact, and fostering positive attitudes towards mathematics among primary school students (Al-Ghanmi, 2022; Abu Sarah, 2019; Hassan, 2019; Al-Saeed, 2018).

Methodology

This study adopted a descriptive approach to examine the research objectives, which involves examining the phenomenon in its natural context to comprehensively describe it. This approach was utilized to develop the study instrument, analyze and interpret existing literature, and subsequently propose suitable solutions.

A. Population and sample

The scope of this study encompassed all mathematics teachers and supervisors of gifted students in public and private schools across in Jordan. This study was conducted in the second semester of the academic year 2022/2023. The aim was to identify the degree of use of Metaverse in teaching mathematics. The study sample encompassed all primary school mathematics teachers and supervisors responsible for gifted students, both in public and private schools in Jordan. The final sample size for this study comprised 64 teachers and 8 supervisors.

Table 1 Distribution of the study sample based on the variable of the nature of the profession.

Nature of the profession	Frequency	Percentage
Teachers	64	%89
supervisors	8	%11
Total	72	%100

B. Training courses in the field of mathematics teaching techniques

Table 2 below shows the number of training courses in the field of mathematics teaching techniques

Table 2 Distribution of the study sample based on the Training courses in the field of mathematics teaching techniques

Training courses	Frequency	Percentage
Not attending any course	14	19.7%
Attend one training course	9	%11.9
Attending two training courses	12	%16.5
Attending more than two training courses	37	%51.9
Total	72	%100

C. The Tool

The questionnaire was utilized as a data collection tool due to its high validity and reliability. The construction and development of the study instrument were based on extensive references to relevant books, articles, and previous studies pertaining to the subject. This process aimed to establish the sub-dimensions of the instrument and accurately capture the realities associated with the utilization of metaverse technology among primary stage students.

The initial draft of the tool was formulated by composing and drafting the items. Subsequently, the tool was refined to its preliminary version by carefully selecting the most suitable and comprehensive items for each dimension. The final version of the tool comprised 25 items.

Verifying the validity and reliability of the instrument

The initial copy of the tool was presented to a panel of 11 experts who specialized in educational technology, curriculum development, and teaching methods. Their role was to assess the validity of the tool and provide their expert opinions regarding its clarity, alignment with the study objectives, item consistency and appropriateness to their respective dimensions. They were also consulted on potential modifications to item wording or the removal of any items they deemed necessary. Based on their opinions, some items were reformulated, and 5 items were omitted.

Furthermore, the instrument was employed in a pilot study involving 15 teachers and 5 supervisors who were not part of the study sample. The responses and feedback gathered from this pilot study were utilized to refine the final version of the instruments. To assess construct validity, Rasch model analysis was employed, as it is a robust tool in evaluating measurement properties. It also, this analytical approach ensure objectivity in psychological and educational measurement.

The collected data were subjected to analysis to evaluate the validity and reliability using the Rasch Model. The analysis involved conducting item polarity analysis using point-measure correlation (PTMEA) to evaluate item consistency. Acceptable values for PTMEA ranged from 0.2 to 1. Furthermore, the Infit and outfit mean square (MNSQ) values were assessed, with values between 0.4 and 1.5 considered appropriate. Standardized fit statistic (Zstd) values were examined, and they were expected to fall within the range of -2 to 2. In terms of dimensionality, the criterion for dimensionality required a minimum of 40% to ensure that the dimensions adequately captured the variation in the data. The unexplained variance in the first contrast was expected to be less than 15%, indicating a coherent dimension structure. Furthermore, item and persons separation were evaluated. The reliability criterion for accepting items exceeded 0.50, indicating acceptable item reliability. The acceptable separation value was set at a minimum of 2, indicating adequate discrimination between individuals (AlAli & Saleh, 2022; AlAli & Al-Barakat, 2022).

The dimensionality data analysis results, presented in Table 3 below, align with the calibration measurement analysis. These findings are consistent with the dimensionality analysis, as the measures account for a raw variance exceeding 40%, and the unexplained variance in the first contrast is below 15%. Therefore, the dimensionality data results are in accordance with the Rasch model.

Table 3. Item Dimensionality of the "Utilization of Metaverse in Teaching Mathematics" Instrument.

		Empirical		**Modeled**
Total raw variance in observations	26.5	100.0%		100.0%
Raw variance explained by measures	9.5	45.8%		35.6%
Raw variance explained by persons	3.7	9.8%		13.8%
Raw Variance explained by items	5.8	21.9%		21.9%
Raw unexplained variance (total)	17.0	64.2%	100.0%	64.4%
Unexplained variance in 1st contrast	2.2	8.3%	12.9%	
Unexplained variance in 2nd contrast	1.9	7.2%	11.2%	
Unexplained variance in 3rd contrast	1.7	6.4%	10.0%	
Unexplained variance in 4th contrast	1.3	4.6%	7.1%	
Unexplained variance in 5th contrast	1.1	4.2%	6.6%	

The instrument's validity was assessed using the MNSQ values for the infit, and the results indicated that the instrument demonstrated an acceptable level of validity. The validity scores of the instrument, as determined by the MNSQ values, fell within the recommended range of 0.4 to 1.5, indicating good fit. This finding is consistent with the item polarity analysis, as indicated by the PTMEA values, which should range from 0.2 to 1. Furthermore, the instrument exhibited an appropriate standardized fit statistic (Zstd) value, falling within the range of -2 to 2, as presented in Table 4 below.

Table 4. Item Fit Analysis for instructional illustrations instrument.

items	Measure	Model S.E	Infit MNSQ ZSTD		Outfit MNSQ ZSTD		Pt-measure	
							CORR	EXP
Item5	0.07	0.04	1.64	1.9	1.90	1.8	0.53	0.52
Item12	0.43	0.05	1.54	1.7	1.67	1.9	0.51	0.48
Item8	0.01	0.05	1.44	1.8	1.44	1.7	0.49	0.54
Item3	0.59	0.05	1.05	0.9	1.06	1.2	0.48	0.47
Item4	0.69	0.05	0.98	1.3	0.96	1.3	0.54	0.48
Item1	0.29	0.05	1.01	1.5	0.96	1.0	0.57	0.52
Item15	0.08	0.04	0.93	1.6	0.94	1.6	0.58	0.51
Item2	0.07	0.05	0.90	1.4	0.88	1.4	0.58	0.52
Item7	0.12	0.05	0.90	1.4	0.87	1.3	0.61	0.54
Item17	0.01	0.04	0.91	1.3	0.90	1.4	0.61	0.55
Item6	0.16	0.07	0.86	1.2	0.87	1.5	0.63	0.54
Item11	0.11	0.04	0.83	1.0	0.80	1.2	0.63	0.53
Item9	0.57	0.05	0.81	-1.2	0.78	1.1	0.64	0.53
Item14	0.12	0.05	0.90	-0.8	0.92	-1.0	0.65	0.59
Item16	0.27	0.04	0.77	-1.1	0.75	-0.9	0.65	0.55
Item10	0.17	0.05	0.76	-1.6	0.73	-1.2	0.66	0.53
Item3	0.37	0.04	0.76	-1.3	0.75	-1.4	0.67	0.56

A five-category scale was utilized for the 'utilization of Metaverse in teaching mathematics' instrument, with the following categories: 1 = Never use, 2 = Almost never, 3 = Occasionally Sometimes, 4 = Almost every time, and 5 = Frequently use. Table 5 and Figure 2 provide a summary of the category structure, illustrating the gradation and size of the intersection related to the utilization of Metaverse in teaching mathematics. The column arrangement in the observation section (observed count) displays the respondents' answers based on the ranking scale. As depicted in Table 5, the most frequently selected response by respondents was scale 4, with a count of 7 (35%). The next most common scale chosen by respondents was scale 3, with 5 (25%) responses. Scale 5 received 4 (20%) responses, while the least frequently selected scale was scale 2, with 3 (15%) responses. Scale 1 had the fewest responses, with 1 (5%) respondents. The observed averages illustrate the pattern of responses, which is expected to follow a fairly normal pattern with a systematic progression from negative to positive, as indicated in Table 5.

Table 5. Calibration scaling analysis of 'utilization of Metaverse in teaching mathematics' instrument.

Category Label	Observed Count %		Observed Average	Infit MNSQ	Outfit MNSQ	Structure Calibration	Category Measure
1	1	5	-0.52	0.94	0.90	None	(-2.55)
2	3	15	-0.12	1.09	1.10	-1.09	-1.15
3	5	25	0.05	0.81	0.70	-0.37	-0.25
4	7	35	0.51	0.89	0.82	-0.30	0.89
5	4	20	1.25	1.20	1.10	1.76	(2.87)

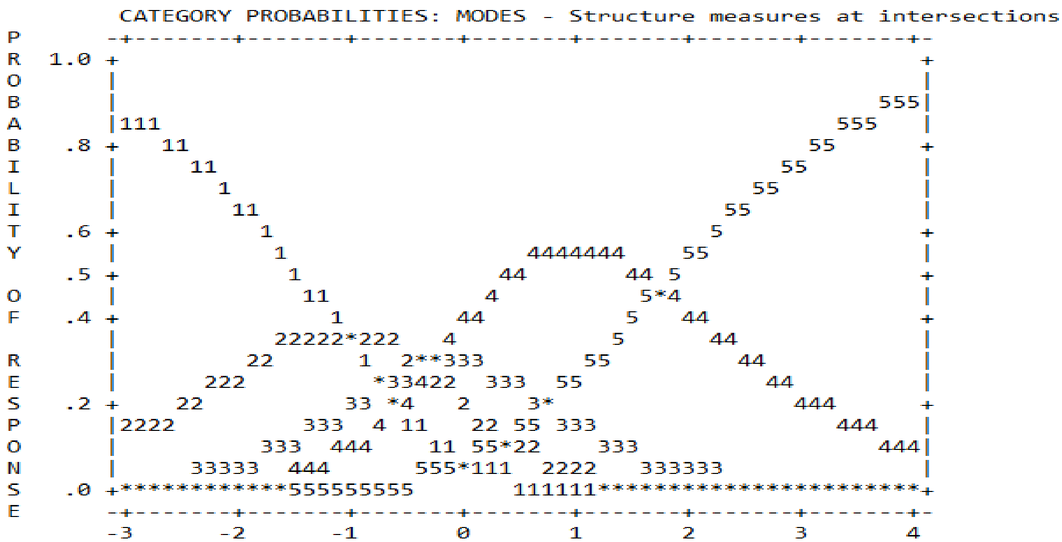

Fig 2. The summary of the category structure of 'utilization of Metaverse in teaching mathematics' instrument.

In order to ascertain reliability using the Rasch model, it is essential to assess both person reliability and item reliability. The reliability criteria should exceed 50% to be considered satisfactory. Additionally, item and person separation values should exceed 2 to be deemed acceptable, as indicated by previous studies (AlAli, Alsoud, Athamna, 2023; Saleh et al., 2023). In this study, the reliability of the scale was evaluated through the measurement of person reliability and item reliability. The findings indicated that the scale demonstrated a satisfactory level of reliability for its items, as depicted in Table 6.

Table 6. Person and Item separation and reliability for 'utilization of Metaverse in teaching mathematics' instrument.

	Score	Count	Measure	Error	Infit		Outfit	
					MNSQ	ZSTD	MNSQ	ZSTD
Mean	58.0	17.0	0.39	0.28	1.02	0.2	1.05	
0.2 S.D	10.6	0.1	0.90	0.10	0.69	2.0	0.79	
2.0 Real rmse	0.34 Adj. sd		0.83 Separation		2.45 Person reliability		0.89	
Mean	979.4	20.0	0.00	0.05	1.00	0.4	1.05	
0.6 S.D	58.0	1.0	0.31	0.00	0.26	1.8	0.45	
1.9 Real rmse	0.05 Adj. sd		0.31 Separation		6.41 Item reliability		0.98	

Findings

To answer the main study question: What is the extent of teachers' utilization of Metaverse technology in teaching mathematics at the primary level, as perceived by both supervisors and the teachers themselves?

In order to assess the extent to which teachers utilized Metaverse technology in teaching mathematics, the study sample's responses to the scale items were analyzed. Frequencies, percentages, standard deviations, and ranks were computed based on these responses. The outcomes are presented in Table 7.

Table 7. Responses of the study sample regarding the extent of teachers' utilization of Metaverse technology in teaching mathematics at the primary level, as perceived by both supervisors and teachers themselves.

N.	Item	Mean	Std. Deviation	Rank
1	The teacher is actively involved in the creation of metaverse content for the mathematics course that he/she is teaching or supervising.	3.39	1.523	6
2	The teacher employs metaverse technology to track and assess students' progress in the mathematics course.	3.35	1.551	7
3	The teacher consistently utilizes metaverse technology throughout the instruction of the mathematics course.	3.31	1.426	8
4	The teacher's utilization of metaverse technology facilitates the exchange of experiences among colleagues.	3.59	1.589	3
5	The mathematics teacher collaborates with colleagues in constructing the content of the metaverse reality, thereby fostering a shared knowledge base.	3.42	1.464	5
6	The utilization of metaverse technology enables the teacher to save time and effort in effectively communicating knowledge.	3.56	1.666	4
7	While utilizing metaverse reality technology, students actively engage in interactive sessions with the teacher.	3.61	1.694	2
8	The incorporation of metaverse technology contributes to the professional development of mathematics teachers.	3.68	1.704	1
	Overall Average	3.49	1.509	
First Dimension: The degree to which teachers employ Metaverse technology in teaching mathematics				
1	I use of virtual Dienes pieces for teaching mathematical concepts (specifically numbers and operations) to students.	4	1.049	3
2	I use virtual Linking Cubes to teach students mathematical concepts (addition, subtraction, and classification).	3.9	1.118	7
3	I use Domino's Virtual Subtraction Facts as a teaching tool to help students understand the concept of subtraction.	3.63	1.237	9
4	I utilize the virtual number line as an instructional tool to teach students the concept of numbers.	3.97	1.166	5
5	I use virtual fraction slides to teach students the concept of fractions, as well as operations performed on them.	3.97	1.172	6
6	I utilize the virtual arithmetic scale as an instructional tool to teach students the concept of mathematical operations.	3.45	1.349	10
7	I utilize virtual clock models to teach students the skill of telling time.	4.02	1.133	2
8	I utilize virtual engineering tools to teach students the art of drawing engineering designs.	4.08	1.055	1
9	I use virtual drawing applications such as GeoGebra and Desmos as instructional tools to teach students the skill of drawing geometric shapes.	3.37	1.448	12
10	I utilize virtual geometric pieces to instruct students in the Geometric Shapes and Spatial Reasoning unit.	3.88	1.168	8
11	I utilize virtual geometric anthropomorphic to teach students in the Geometric Shapes unit.	3.98	1.135	4
12	I utilize virtual calculators to enhance students' learning experience when calculating the area of a circle.	3.35	1.390	13
13	I utilize the virtual Geoboard as an instructional tool to teach students how to draw geometric shapes.	3.41	1.399	11
	Overall Average	3.77	0.3839	-
Second Dimension: The degree to which teachers use Metaverse technology in teaching mathematics				

The analysis of the Table 7 reveals that the employment of Metaverse technology by teachers in teaching mathematics, as perceived by both supervisors and teachers themselves, was relatively high. The overall average score was 3.49 out of 5, indicating a mean falling within the fourth category (3.41-4.22) on the five-point scale. This average corresponds to the fourth category on the five-point scale, which represents "Almost every time use" according to the study tool. The standard deviation of 1.509 suggests a degree of consensus among teachers and supervisors regarding the extent of teachers' adoption of Metaverse technology in mathematics instruction. Most of the items received high scores, except for items 1, 2 and 3, which obtained moderate scores. This simple disparity in opinions reflects the varying perspectives of the sample on those particular items.

Table 7 clearly indicates that the degree of teachers' utilization of Metaverse technology in teaching mathematics, as perceived by both supervisors and teachers themselves, was remarkably high. The overall average score of 3.77 out of 5 corresponds to the fourth category on the five-point scale, signifying "Almost every time used" according to the study tool. According to the sample's feedback, the most notable items pertaining to the extent of teachers' utilization of Metaverse technology in teaching mathematics were ranked as follows: item 8, item 7, and item 1, in descending order of approval. Regarding the items with the lowest scores in terms of teachers' utilization of the Metaverse technique in teaching mathematics, they corresponded to items 12, 9, and 13 in descending order.

To address the second inquiry, which examines potential statistically significant differences in perspectives between supervisors and teachers regarding the utilization of Metaverse technology in primary-level mathematics instruction based on academic qualification, experience, and training, statistical analyses such as t-tests and one-way analysis of variance (ANOVA) were conducted. The outcomes of the t-test, illustrating the extent of Metaverse technology utilization in teaching mathematics at the primary level as perceived by supervisors and teachers, categorized by academic qualification, experience, and training, are presented in Table 3.

Table 3. Means, Standard Deviations, and t-Values for Sample Responses on the Utilization of Metaverse Technology in Teaching Mathematics at the Primary Level, Categorized by Academic Qualification.

Dimensions		**N**	**Mean**	**Std. Deviation**	**t-Value**	**Sig.**
employing Metaverse technology in teaching mathematics	Bachelor's	51	2.55	1.528	2.049	0.056
	Postgraduate	21	1.88	1.140		
Using Metaverse technology in teaching mathematics	Bachelor's	51	2.58	1.515	2.423	0.101
	Postgraduate	21	1.81	1.308		
Overall average	Bachelor's	51	2.57	1.525	2.317	0.068
	Postgraduate	21	1.87	1.331		

According to the findings presented in Table 3, there are no statistically significant differences observed in the mean scores of respondents regarding the utilization of Metaverse technology in teaching mathematics at the primary level based on their academic qualification.

Table 8 below shows the results of one-way analysis of variance for the degree of availability of actively open-minded thinking indicators on the results of gifted programs in the dimensions of the scale due to the number of programs acquired by the gifted students.

Table 8. Results of Analysis of Variance of Differences between the Means of Responses of Sample concerning the utilization of Metaverse technology in teaching mathematics at the primary level based on training and experiences.

Variance Source			Sum of Squares	df	Mean Square	F	Sig.
Training	employing Metaverse technology in teaching mathematics	Between Groups	57.893	2	28.946	14.656	.000
		Within Groups	347.59	176	1.975		
		Total	405.49	178			
	Using Metaverse technology in teaching mathematics	Between Groups	7.877	3	2.626	3.852	.010
		Within Groups	175.88	258	.682		
		Total	183.76	261			
	Whole Dimensions	Between Groups	15.439	3	2.173	3.192	.010
		Within Groups	235.514	193	.871		
		Total	139.086	199			
Experience	employing Metaverse technology in teaching mathematics	Between Groups	7.093	2	3.546	1.567	.212
		Within Groups	298.39	176	2.264		
		Total	305.49	178			
	Using Metaverse technology in teaching mathematics	Between Groups	3.601	2	1.800	4.661	.110
		Within Groups	222.89	277	.386		
		Total	226.49	279			
	Whole Dimensions	Between Groups	3.419	3	1.481	3.126	.130
		Within Groups	135.52	96	.377		
		Total	139.34	99			

According to the findings presented in Table 8, there are no statistically significant differences observed in the mean scores of respondents regarding the employment of Metaverse technology in teaching mathematics at the primary level based on their experiences. While, statistically significant differences are observed in the perspectives of teachers and supervisors regarding the extent of utilizing the Metaverse technique in teaching mathematics at the primary stage. These differences are observed when considering the training variable. To determine the direction of differences in favor of any category, the Scheffe test of the post-comparisons was used to find out the four period of courses acquired.

Table 9 Results of Scheffe test for Differences between the number of courses acquired by the teachers

(I) Course	(J) Course	Mean Difference (I-J)	Sig.
0 course	1 course	.23726	.659
	2 course	.25884	.511
	more than 2 course	-.15524	.722
1 course	0 course	-.23726	.659
	2 course	.02158	.914
	more than 2 program	-.39250	.130
2 course	0 course	-.25884	.511
	1 course	-.02158	.914
	more than 2 program	-.41408	.044
more than 2 course	0 course	.15524	.722
	1 course	.39250	.130
	2 course	.41408	.044

Based on the findings presented in Table 9, significant statistical differences are apparent in the perspectives of teachers and supervisors regarding the utilization of Metaverse technology in primary-level mathematics instruction. These differences are observed when considering the training variable, specifically between individuals who received one course and those who received more than two courses. Notably, the viewpoints of those who received more than two courses favor a greater extent of utilizing Metaverse technology compared to those who received only one course. However, the analysis revealed no statistically significant differences in the perspectives of teachers and supervisors regarding the extent of utilizing Metaverse technology in teaching mathematics at the primary level for the remaining categories of the training variable.

Discussion

The findings of the first question revealed that, according to both supervisors and teachers, there was a relatively high level of utilization of Metaverse technology in teaching mathematics at the primary level. This observation can possibly be attributed to teachers' recognition of the inherent value of Metaverse technology in the educational context, as well as their receptiveness towards adopting novel and beneficial tools within the domain of educational technology to enhance and streamline the teaching process. Enhanced Student Engagement: Metaverse technology provides interactive and immersive learning experiences that captivate students' attention. Through the use of simulations, virtual environments, and augmented reality, students can actively participate in their learning, leading to increased engagement and motivation. This high level of engagement is recognized by supervisors and teachers as a positive aspect of utilizing Metaverse technology in the mathematics classroom. Improved Conceptual Understanding: Metaverse technology offers visual representations, interactive models, and simulations that support students' conceptual understanding of mathematical concepts. These visual and interactive tools make abstract concepts more tangible and accessible, enabling students to explore and manipulate mathematical ideas in a way that promotes deeper understanding. Supervisors and teachers appreciate the potential of Metaverse technology to enhance students' conceptual grasp of mathematics. Personalized Learning Opportunities: Metaverse technology allows for personalized learning experiences tailored to individual students' needs. Teachers can create customized activities, adaptive assessments, and targeted feedback that cater to different learning styles and levels of proficiency. This personalized approach ensures that students receive the necessary support and challenges to optimize their learning outcomes. The ability of Metaverse technology to facilitate personalized learning is valued by supervisors and teachers. Collaboration and Communication: Metaverse technology encourages collaboration and communication among students. It provides opportunities for cooperative problem-solving, group projects, and peer interaction within virtual environments. Supervisors and teachers recognize the importance of collaboration and communication skills in mathematics education, and they appreciate how Metaverse technology facilitates these essential aspects of learning. Technological Relevance: Metaverse technology aligns with the digital fluency of today's students. It reflects the use of technology in their daily lives and capitalizes on their familiarity with digital tools. Supervisors and teachers recognize the importance of integrating technology into education to meet the needs and expectations of modern learners. Professional Development and Support: Supervisors may provide professional development opportunities and support to teachers in effectively integrating Metaverse technology into their mathematics instruction. This training and guidance enable teachers to develop the necessary skills and confidence to implement

Metaverse technology effectively in the classroom. Supervisors and teachers appreciate the value of ongoing professional development in utilizing technology for teaching mathematics.

This suggests that educators recognize the potential benefits and value that Metaverse technology brings to the teaching and learning process in the field of mathematics. Metaverse technology offers interactive and immersive experiences, allowing students to engage with mathematical concepts in a dynamic and visually stimulating manner. It can provide opportunities for hands-on exploration, problem-solving, and collaboration, fostering deeper understanding and retention of mathematical principles. By incorporating Metaverse technology into their instructional practices, teachers can create interactive virtual environments, simulations, and activities that cater to diverse learning styles and promote active student engagement. This can lead to enhanced student motivation, participation, and ultimately, improved learning outcomes in mathematics. Moreover, the positive perception of Metaverse technology among both supervisors and teachers suggests a readiness and openness to embrace innovative teaching methods. This willingness to explore and integrate emerging technologies in the classroom reflects a commitment to adapt teaching practices to meet the evolving needs and preferences of students in the digital age. This result is consistent with the study by (Rojas et al., 2023; Şeyma & Özdemir, 2022; Al-Ghanmi, 2022; Boz and Özerbaş, 2020; Özdemir and Özçakır, 2019; Abu Sarah, 2019; Hassan, 2019; Al-Saeed, 2018).

The findings from the second question revealed statistically significant variances in the perspectives of teachers and supervisors concerning the extent of Metaverse technology utilization in primary-level mathematics instruction. These distinctions were observed based on the training variable, favoring individuals who received more than two courses.

The researchers attribute this outcome to several factors. Firstly, they suggest that the higher degree of Metaverse technology usage among teachers in mathematics instruction can be attributed to the curriculum's increased emphasis on this technology and its ease of implementation compared to conventional methods of conveying information and exploring mathematical concepts. Additionally, the utilization of Metaverse technology captures students' attention, enhances their focus, and fosters their acquisition of experience and knowledge, thereby promoting the development of self-learning skills.

It also, the statistically significant differences in the viewpoints of teachers and supervisors regarding the extent of using Metaverse technology in teaching mathematics at the primary level, based on the training variable, can be attributed to several reasons: first, increased familiarity and comfort: Teachers who received more than two courses on Metaverse technology likely had a higher level of familiarity and comfort with using the technology in their teaching practices. This enhanced familiarity could lead to a more positive perception of its effectiveness and potential benefits in mathematics instruction. Second, enhanced pedagogical strategies: teachers who have undergone multiple training courses on Metaverse technology are likely to have acquired a deeper understanding of its pedagogical implications. They may have learned effective instructional strategies and techniques specific to Metaverse technology, enabling them to leverage its full potential in teaching mathematics. This deeper knowledge and expertise can influence their positive perception of its usefulness. Third, confidence in implementation: teachers who have received extensive training on Metaverse technology may feel more confident in implementing it in their classrooms. This confidence can positively impact their perception of the technology's efficacy and encourage its more extensive use in mathematics instruction. Fourth, higher skill acquisition: teachers who have undergone multiple courses on Metaverse technology are likely to have acquired a broader range of skills related to its implementation. These skills may include designing engaging Metaverse experiences, integrating mathematical content effectively, and troubleshooting potential technical issues. The acquired skills contribute to a more positive perception of the technology's utility in mathematics instruction. Fifth, peer influence: Teachers who have undergone multiple training courses may have had opportunities to collaborate and share experiences with peers who have similar training backgrounds. Peer interactions can influence perceptions and promote a positive attitude towards using Metaverse technology in teaching mathematics. Sixth, technological competence: Teachers who have undergone multiple training courses are likely to have developed a higher level of technological competence in using Metaverse technology. They may have gained proficiency in operating the necessary tools, troubleshooting technical issues, and effectively integrating the technology into their instructional practices. This competence can enhance their confidence and positive outlook towards using the technology in mathematics teaching. Seventh, knowledge transfer: teachers who have received more training courses on Metaverse technology may have had more opportunities to engage in professional development activities, attend workshops, or collaborate with experts in the field. These experiences can facilitate knowledge transfer, enabling them to stay updated with the latest advancements and best practices in using Metaverse technology for mathematics instruction. This result is consistent with the study by (Al-Mutairi & Rizk, 2022; Al-Harithi & Al-Issa, 2022; Al-Anazi & Massad, 2018; Al-Qahtani, 2010).

It is crucial to acknowledge that these statistically significant differences do not imply that teachers with fewer training courses hold negative views or possess lesser capabilities. Rather, these differences reflect varying levels of exposure, knowledge, and experience with Metaverse technology, which can influence one's perspective on its application in mathematics instruction. Each individual's unique background and opportunities for professional development contribute to their outlook and understanding of the potential benefits and challenges associated with utilizing Metaverse technology in the classroom.

The findings also revealed that no statistically significant differences were observed based on the teachers' experiences with Gifted Students.

This is attributed to the fact that teachers encounter similar teaching conditions when instructing mathematics, without any consideration given to their experience levels. Due to the inherent complexity of mathematics, it serves as a common denominator among all mathematics educators. Consequently, they encounter comparable challenges and tend to employ comparable teaching methods and educational techniques to facilitate students' comprehension of the subject. These findings are consistent with several studies conducted by Al-Mutairi & Rizk (2022), Al-Harithi & Al-Issa (2022), Al-Anazi & Massad (2018), and Al-Masaad & Al-Afeisan (2017). Collectively, these studies demonstrate that there were no significant differences in the average responses of science teachers concerning the actual implementation of modern technologies based on their years of experience.

D. Recommendations and Future Directions

Based on the findings of the present study, several recommendations have been put forth by the researchers to enhance the utilization of Metaverse technology in teaching mathematics at the primary level, as perceived by both supervisors and teachers. The following recommendations are proposed:

Implementing continuous professional development initiatives that specifically target Metaverse technology. These programs should be designed to encourage teachers to actively participate in ongoing training sessions and professional development programs. By doing so, teachers can enhance their skills, expand their knowledge, and remain up-to-date with the latest advancements in leveraging Metaverse technology for the effective instruction of mathematics. To promote the effective integration of Metaverse technology in teaching practices, it is recommended to cultivate collaborative learning communities among teachers and supervisors. This can be achieved by creating platforms and opportunities that facilitate the sharing of knowledge and exchange of best practices pertaining to Metaverse technology. Encouraging regular communication and collaboration within these communities can enable teachers to learn from one another, gather insights, and collectively develop innovative approaches for the seamless integration of Metaverse technology into their instructional practices.

Conducting a comparative analysis to determine the extent of metaverse technology utilization among gifted and ordinary students in middle and high school levels. Conducting future studies on the potential barriers to implementing metaverse technology in primary school education. Conducting evaluation studies on the training programs implemented by education departments pertaining to the utilization of metaverse technology in teaching. Conducting analytical studies on the primary stage curricula focusing on its alignment with the developmental needs of students at this stage, particularly in relation to the integration of metaverse technology in teaching.

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