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The Metaverse in mathematics education: The opinions of secondary school mathematics teachers

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Highlights

- Metaverse will be in almost every sector in the coming years
- Using metaverse technologies in educational settings increases student achievement, positive attitude towards courses, motivation, concretization, and permanent learning.
- Teachers' opinions about the availability of the Metaverse in mathematics education are generally positive.
- Metaverse can be used mainly for concretization and geometry.

Article Info: Research Article

Keywords: *Metaverse, Meta-education, Secondary school mathematics teachers*

Abstract

With the Covid 19 pandemic, technology-supported applications have been quickly integrated into education. At this point, Metaverse will inevitably be involved in the education sector. The need to determine the knowledge, attitudes, and awareness of our teachers, the practitioners of education, about the concept of metaverse has arisen. The convergent parallel mixed method, which allows simultaneous collection of quantitative and qualitative data, was used. 70 mathematics teachers who teach in different regions of Türkiye and secondary schools, selected by the easily accessible case sampling method, participated in the study. A semi-structured form prepared by the researchers was used to collect the data. The first part of the interview form is the "Metaverse Scale" and the second part is one closed-ended and three open-ended questions. Quantitative data were analyzed by using descriptive statistics included in and t-test for independent samples, while qualitative data were analyzed by content analysis. Teachers' opinions about the availability of the Metaverse in mathematics education are generally positive, and they indicate that it can be used mainly for concretization, geometry and they find it useful. The reasons for the lack of research on the concept of the Metaverse are themed as personal reasons, negative attitudes, Metaverse-related causes, and lack of resources, and explanations are made mostly for personal reasons. Knowledge, attitudes, and awareness scores regarding the concept of metaverse do not differ significantly by gender; female and male mathematics teachers have similar views, The results of the research also shed light on the future of students studying in different conditions in different regions of the country following the opinions of mathematics teachers who perform their duties in different regions of Türkiye.

1. Introduction

The concept of the metaverse, which has recently attracted attention, consists of a combination of the words "meta" and "universe" and was first mentioned in the science fiction novel Snow Crash (Stephenson, 1993). The Metaverse is a virtual structure in which participants participate in a virtual environment regardless of

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space and time or interact with each other through self-created avatars to reproduce real life (Díaz, Saldaña, & Avila, 2020). The concept of the Metaverse refers to an immersive virtual environment in which a person can interact with avatars (Suh & Ahn, 2022).

Founded in 2003," Second Life" (SL) is an internet-based three-dimensional virtual environment inspired by the science fiction novel Snow Crash (Şahin, 2016). In this game, users could travel with their avatars in a digital environment, interact with other users, and perform actions they could not do in everyday life in a virtual world. The players, feeling they have a second life, have bought a plot or engaged in many activities, such as selling digital artifacts (Şahin Orkunoğlu & Çiftçi, 2022).

Roblox, the online gaming platform established in 2006, is an important gateway to the metaverse environment (Çelik, 2022). It is possible to say that students are actively involved in gaming platforms with many users today. The research shows that 54.86% of daily active users of Roblox, which has 202 million monthly users, are under the age of 13, and 13% are between the ages of 13-16 (Dean, 2021). It is known that teachers need to understand their students well to provide quality education, and for this, teachers need to understand that the Metaverse is deeply embedded in students' lives (Suh & Ahn, 2022).

The reappearance of the Metaverse happened with OASIS, which was set in the science fiction novel Ready Player One (Start), written by Ernest Cline in 2011. OASIS is a multi-user online Virtual Reality (VR) game where users can connect to OASIS by wearing their headphones, tactile gloves, and costumes (Mystakidis, 2022). Cline's novel was adapted into a film and met with the audience in 2018.

One of the important reasons why the awareness of the metaverse concept has increased recently is that the global Covid-19 pandemic has accelerated the transition to the digital environment (Kang, 2021), and another is that Facebook has changed its name to Meta and made definitions about the metaverse (Kalkan, 2021).

2. Literature

The dimensions of the metaverse concept are shown in Figure 1. Mixed reality (MR) can bridge the connectivity of social media with the unique possibilities of VR and Augmented Reality (AR) technologies. If their interaction is creatively unleashed, it is expected to shape many industries, including distance online education (Mystakidis, 2022). As Mystakidis states that

> *"The high cost of equipment is a barrier to mass adoption that is expected to be mitigated in the long run. Risks related to AR can be classified into four categories related to (i) physical well-being, health and safety, (ii) psychology, (iii) morality and ethics and (iv)data privacy. Argue that immersion with interaction in 3D virtual worlds leads to the additional affordances of identity construction, presence and co-presence. The construction of an online identity is achieved primarily through the digitally embodied representation of the self in virtual worlds, the avatar. Common principles of the Metaverse include software interconnection and user teleportation between worlds. This necessitates the interoperability of avatar personalization and the portability of accessories, props and inventory based on common standards."*

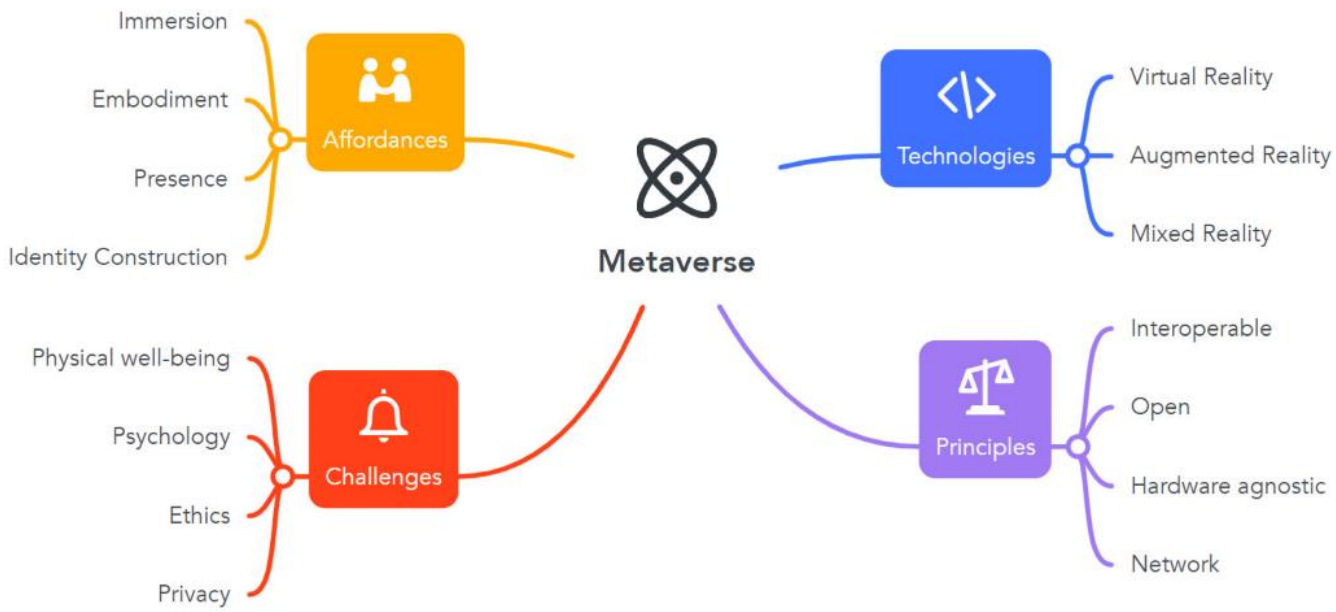

Figure 1. Technologies, principles, affordances, and challenges of the Metaverse (Mystakidis, 2022)

VR, AR and MR constitute the technology dimension of the Metaverse. VRprovides an immersive environment that brings objects into the non-real world, while AR combines information with the real world (Lee, 2021). On the other hand, MR is a virtual environment that combines VR and AR elements (Cabero-Almenara, Barroso-Osuna, & Martinez-Roig, 2021).

2.1. Studies on the metaverse in the literature

Damar (2021) conducted a bibliometric evaluation of metaverse technology by deciphering all the documents in the Web of Science database between 1990 and 2021 in his study. He noted that studies hadpeaked in recent months, and interest has been shown in the metaverse concept in the education and digital marketing sectors. In addition, it has been found that there is an intensity related to VR and ARtechnologies. He has inferred that it will enter many areas of life and shape life in the next 15-20 years.

In his study, Kuş (2021) aimed to reveal users' perceptions about the metaverse concept. The comments below a Turkish video with the most views about the metaverse on the YouTube video platform have formed the study's data. He analyzed the comments and user interactions that included the perception of opportunity and concern for the Metaverse concept using the content analysis method. At the end of the study, positive and negative themes were determined, and results about the perception of opportunity and anxiety were included.

Türk, Bayrakçı, & Akçay (2022) conducted a study on the metaverse and self-presentation. In their study, Web 3.0, which is required in the construction of the Metaverse, VR, AR, MR, and NFT (non-fungible token), the world's leading clothing brands new products through new technologies such as self-presentation in the context of consumer culture are explained with examples of how to do it. As a result of the research, it was stated that both interpersonal communication processes and all types of relationships would be perceived as happening in the real world. Metaverse users are expected to present themselves in this environment with showcase performances to feel valued and belong, to be approved, and to experience all kinds of emotions in the future. For this purpose, it is seen that they will create and present their status, socio-economic classes, identity, and image through NFTs.

The study conducted by Özkahveci, Civek, & Ulusoy (2022) aimed to determine individuals' level of interest in the Metaverse. For this purpose, the concept of the Metaverse has been decisively analyzed in the categories "news" and "shopping" by using Google Trends data for the years 2016-2021. In the study, when comparing according to the years, it was seen that searches increased after the period when Facebook changed its name to Meta in 2021. As a result, it has been concluded that the Metaverse is progressing by putting it on every passing year around the World and that people's curiosity and desire for this fictional universe are increasing.

Göçen (2022) stated in her review that the studies conducted about the metaverse in Türkiye usually focus on platforms such as VR, augmented reality, and Second Life.

In his research, İlic (2013) aimed to evaluate the participants' views on the learning environment and examine their problems experienced in this environment by designing a three-dimensional learning environment in the Second Life environment for use in foreign language education. As a result of the research conducted with 24 volunteer teacher candidates, the designed learning environment was found fun, engaging, and useful by the participants. At the same time, it was concluded that the Second Life environment could improve the speaking skills of people in language education.

Çetin (2019) aimed to determine the effect of Second Life application on students' motivation to learn e-commerce in his research. As a result of the study conducted with 111 participants consisting of students of the faculty of economic and administrative sciences, it was found that Second Life positively affects student motivation.

In another study on Second Life, Şahin (2016) investigated the usability of the Second Life game in teaching social science.An exemplary learning environment was designed with the experiential learning model in the study conducted with pre-service teachers from different grade levels studying in the Department of Social Science Teaching. Then the experiences and opinions of the pre-service teachers in the environment were taken.It has been determined that the social science education conducted on the Second Life platform increases the interest and motivation of pre-service teachers in the lesson and provides tangible and lasting learning.At the same time, it was concluded that it saves the lesson from routine and increases the self-efficacy levels of pre-service teachers.

34 fifth-grade students participated in the study by Şimşek, Erbay, & Kirişçi (2019) to examine the effect of the Second Life virtual environment on the teaching of fractions at the 5th-grade level.First, the students were pre-tested, and then 3 courses of Second Life were applied in the computer laboratory with the students. After the application, the final test was applied, and it was seen that there was an increase in the scores obtained by the students from the success test. At the same time, it was concluded that the" Snow Dogs" activity attracts students' attention more than traditional methods.

As of March 2022, the Second Life virtual game platform has become the first "Metaverse" platform to require its users to apply taxes. In this context, it is expected that the activities carried out in the Internet environment will be covered by the tax in the coming days. In this context, it is expected that the activities carried out on the Internet will be included in the scope of tax in the coming days. It is known that some services offered in digital environments in Türkiye are within the scope of the March 2020 digital service tax. In the future, commercial transactions such as buying and selling cryptocurrency and NFT are also likely to be covered by taxes. In addition, with the completion of the legal infrastructure of the Central Bank's Digital Currencies, the digital lira is expected to be available in 2022. In order to support all digital developments, 5G infrastructure should be switched in Türkiye as soon as possible, and security infrastructure should be provided to ensure the cyber security of personal data (Şahin Orkunoğlu & Çiftçi, 2022).

Durak & Karaoğlan Yılmaz (2019), in their study, aimed to examine the views of 7th and 8th-grade students on ARapplications.In the interviews with 43 students, it was stated that the codes of "providing a fun

learning environment" and "making the learning process remarkable and effective" came to the fore in the theme of the contribution of ARto the learning process.Lack of smartphone ownership/access was among the students' difficulties. It was concluded that the students thought using ARin science, geometry, and mathematics lessons would be beneficial.

In their study, Özdemir, & Özçakır (2019) aimed to investigate the mathematics achievement of students who learned the subject of fractions with AR applications and the change in their attitudes towards mathematics.In the study conducted with 60 5th graders, it was found that there was a significant difference in the students' achievements. It was concluded that the success scores of the students increased, and their attitudes changed positively towards the mathematics course conducted with AG.

In his study, Altıok (2020) aimed to investigate the effect of mobile augmented reality-supported mathematics education on the achievements of primary school students and their views on the educational process integrated with mobile augmented reality.23 students at the 3rd grade level of the primary school participated in the research. As a result of the research, it was determined that their success in creating symmetry and the concept of symmetry increased.It has been determined that mobile ARhas positive results such as embodying abstract concepts, making the lesson fun, facilitating learning, etc.However, it is stated that there are negative consequences of students having reservations about using technology, not being able to use the device, etc. As a result, it was concluded that with the support of AR, students' learning was facilitated, their performance increased, and AR had a positive and significant effect on the learning process.

Mutluoğlu, & Erdoğan (2021) investigated whether the virtual manipulative team they developed affected the 6th-grade students' achievement in mathematics and their attitudes towards geometry.The research used a quasi-experimental design with the pre-test-post test control group, one of the quantitative research methods.At the end of the research, it was found that the students who underwent the learning process with virtual manipulative had higher academic success in mathematics lessons than in the control group, and their attitude scores towards geometry increased.

Lee, Woo, & Yu (2022) have developed an aircraft maintenance simulation to address the lack of existing distance education system applications. One group received training via remote video, while the other received training via this system. At the end of the training, the knowledge acquisition and retention tests were applied to the groups, and the simulation group scores were higher in both tests. The presence questionnaire concluded that the participants confirmed their sense of spatial presence and that the system was usable.

To meet the expectations of generation z children born in the digital age, it is thought that education provided by traditional methods is insufficient and that educational environments should be supported with advanced technologies. In this context, it is thought that it would be useful to integrate AR into learning environments (Somyurek, 2014).

Cabero-Almenara, Barroso-Osuna, & Martinez-Roig (2021) aimed to deconstruct the possibilities of MR, a combination of AR and VR in university education, in their study.For this purpose, 44 first-year architecture students who took the "Mathematical Fundamentals of Architecture" course analyzed the degree of acceptance of the vehicle used and the technology used, according to the Technology Acceptance Model.The study concluded that MR significantly affects perceived usefulness and ease of use. They found that the use of MRI positively affected students' perceptions of mastery in technology and the processes of teaching mathematics in architecture. In addition, it was stated in the research that support should be offered to university teachers who encourage the use of active MRI-based methodologies in university classrooms.

In their study, Boz & Özerbaş (2020) investigated the opinions of classroom teachers about the use of technology in mathematics lessons. The study's sample, which used a mixed method, was made up of 125 classroom teachers.As a result of the research, it was seen that the classroom teachers thought positively

about the use of technology in mathematics teaching at a rate of 84.2%.Generally, it has been understood that primary school teachers have a positive view of 81%percentregarding the use of technology in teaching mathematics.

Classroom teachers have stated that using interactive whiteboards in mathematics lessons embodies abstract concepts, provides equality of opportunity, attracts attention, and increases permanence. At the same time, they noted that technological tools and equipment increase the interest and desire of students for the lesson. It has been found that classroom teachers need the most tools: the Internet, a computer, a video player, an interactive board, and a calculator. In addition, they stated that the technological tools and equipment used in the mathematics course should be appropriate for the semester's needs.

2.2. The importance and purpose of the research

Metaverse promises to transform many industry sectors, including distance online education. New Meta-educational models may emerge to allow for rich, mixed formal and non-formal learning experiences in Metaverse-supported online distance education and online 3-D virtual campuses (Mystakidis, 2022).In this regard, online learning in the Metaverse will eliminate the need to be physically present in a classroom. It is believed that the avatar will ensure the accuracy of body language and facial expression, as well as virtual participation, will be equally effective. The Metaverse's mixed social reality can make blended active pedagogies possible that nurture deeper and lasting knowledge. More importantly, it ensures participation in education on equal terms worldwide by providing a democratic environment without geographical restrictions.

It is stated in the field article that the Metaverse is not a new concept. Metaverse is expected to be widely available in the education sector along with its subcomponents. It is pointed out that concepts such as race, gender, and physical disability should be weakened in the Metaverse universe (Kuş, 2021).

It should be noted that the difficulties experienced in education during the Covid-19 process (inability to focus, inability to follow lessons, inability to communicate effectively, inability to participate in class, lack of assessment, etc.) it is also envisaged that can be overcome in this way.Proceeding from this, theyneed to determine the knowledge, attitudes, and awareness of our teachers and practitioners of education about the concept of the Metaverse was born.

In this context, the problem of the research was determined as "What are the secondary school mathematics teachers' knowledge, attitude, and awareness scores regarding the concept of Metaverse, and what are their views on the concept and use of Metaverse in mathematics education?".

In the quantitative dimension of the research;

1. What are the scores of secondary school mathematics teachers on the concept of the metaverse and their scores on technology, digitalization, social and lifestyle sub-dimensions?

2. Do the knowledge, attitude, and awareness scores of secondary school mathematics teachers related to the concept of the Metaverse differ according to gender?

The answer to the sub-problems has been sought. In the qualitative dimension of the research,

1. What are the reasons why secondary school mathematics teachers do not need to research the Metaverse?

2. What is the perception of secondary school mathematics teachers who research the metaverse regarding the metaverse concept?

3. What are the opinions of secondary school mathematics teachers about the availability of the Metaverse in mathematics education (mathematics lessons)?

The answer to the sub-problems has been sought.

3. Methodology

3.1. Research Model/Design

In order to obtain different but complementary data on the subject investigated in the study, a converging parallel mixed method was used. This mixed method allows for simultaneously collecting quantitative and qualitative data (Creswell & Plano Clark, 2018). Examining whether the findings support each other, the data are combined, and a wealth of data is provided. A scanning pattern was used in the quantitative dimension of the research, while a case study was used in the qualitative dimension. The descriptivemethod is a research method that allows determining the characteristics of participants, such as opinions, interests, skills, abilities, and attitudes related to a subject (Büyüköztürk, Çakmak, Akgün, Karadeniz, & Demirel, 2019) . Yin (1984) defines a case study as a qualitative research method used in cases where the boundaries between the phenomenon and the context in which it is located are not decisively obvious, and there are multiple sources of evidence or data working within the framework of the current phenomenon's own reality (Yıldırım & Şimşek, 2021).

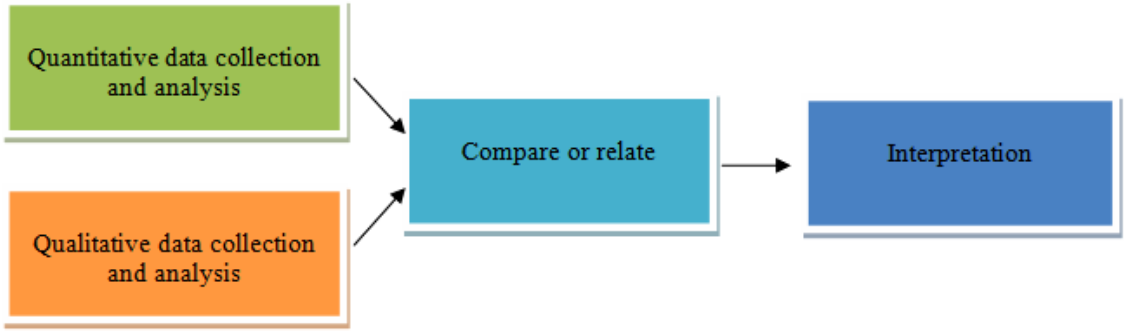

Figure 2. Convergent parallel design (Creswell & Plano Clark, 2018)

3.2. Data Collecting Tools

The researchers prepared a semi-structured form that allowed the collection of quantitative and qualitative data. The "Metaverse Scale" prepared by Süleymanoğulları, Özdemir, Bayraktar, & Vural (2022) was used in the quantitative dimension of the interview form. In the study of Süleymanoğulları et al. (2022), they aimed to develop a measurement tool in order to determine the knowledge level and awareness of individuals about the metaverse. The Metaverse scale comprises 15 items and has four sub-dimensions: technology, digitalization, social, and lifestyle. While the Cronbach alpha reliability coefficient of the scale was stated as .813 by Süleymanoğulları, et. al (2022), the Cronbach alpha reliability coefficient was calculated as .929 in this study. In the study of Süleymanoğulları, et. al (2022); Cronbach alpha value for technology factor .805; Cronbach alpha value for digitization factor .732; Cronbach alpha value for the social factor was .705 and the Cronbach alpha value for the lifestyle factor was .713. The metaverse scale is a 5-point Likert type, and the scoring of the answers; 1 = do not agree, and 5 = agree.. While the lowest score obtained from the scale is 15, the highest score is 75. As the scores from the scale increase, the level of knowledge, attitude, and awareness about the metaverse concept also increase. In the qualitative dimension of a semi-structured form, one closed-ended and 3 open-ended questions were included. Interview questions were prepared in order to compare the answers given by the individuals to the metaverse scale with the answers they gave to the interview questions and to provide detailed information. During the preparation of qualitative interview questions, opinions were obtained from 2 field education and 1 measurement evaluation expert, and the final version of the interview form was given following the

expert opinions and suggestions. The teachers' responses to the interview form were received between 06/06/2022 and 16/06/2022 via the google forms platform.

3.3. Study Group

In the research, convenience sampling was used. This sampling method allows the researcher to work with a group that is easily accessible and thus speeds up the research (Yıldırım and Şimşek, 2021). 33 male, 37 female mathematics teachers working at the secondary school level in different cities of Türkiye participated in the study. When the demographic information of teachers related to professional experience was examined, it was found that 68.6% had 1-5 years, 10% had 6-10 years, 8.6% had 11-15 years, 8.6% had 16-20 years, and 4.3% had 21 years of professional experience.

3.4. Data Analysis

Quantitative data were analyzed using descriptive statistics in SPSS 24.0 program and a t-test for independent samples. Qualitative data were analyzed by content analysis.Content analysis has been defined as a technique in which some words of a text are summarized with smaller content categories, and inferences are made systematically and objectively with certain rules-based encodings. (Büyüköztürk et al., 2019). The researchers examined the consistency between the evaluations by deciphering the thematic coding separately.Consistency was observed between the determined codes and themes, and the compliance rate was calculated as 93% according to Miles & Huberman's (1994) (Consensus/ (Dissensus + Consensus)) ×100 formula. Consensus among coders is expected to be at least 80% to ensure internal consistency. (cited by Baltacı, 2017). Reliability was provided for the analysis of qualitative data.The findings from the analysis were presented with frequency distributions, and the teachers' opinions were directly quoted and sampled. When transferring teachers' opinions, abbreviations such as T1, T2, ..., and T70 were used instead of their names.

4. Findings

4.1. Findings related to the quantitative dimension of the research

In the quantitative dimension of the research, the scores of secondary school mathematics teachers regarding the concept of the Metaverse and the scores they received from the technology, digitalization, social, and lifestyle dimensions are the sub-dimensions of the metaverse, were investigated for the first time. Accordingly, the descriptive findings of scores related to the concept of the Metaverse are given in Table 1.

Table 1.

Descriptive findings related to scores related to the concept of Metaverse

	N	Minimum (f)	Maximum (f)	Mode (f)	$\bar{X}$	Standard Deviation
Technology dimension	70	7.00 (1)	35.00 (1)	29 (8)	23.657	6.917
Digitalization dimension	70	3.00 (5)	15.00 (3)	7 (10)	8.800	3.528
Social Dimension	70	2.00 (7)	10.00 (9)	6 (13)	6.614	2.373
Lifestyle dimension	70	3.00 (8)	15.00 (14)	14(14) 15(14)	11.014	4.203
Total	**70**	**15.00 (1)**	**71.00 (2)**	**52 (6)**	**50.085**	**14.428**

According to Table 1, the highest score obtained by secondary school mathematics teachers from the scale was 71.00, and the lowest score was15.00. It was determined that there were 2 teachers with a score of 71.00 on the scale, 1 teacher with a score of 15.00, and 6 teachers with a score of 52.00 (mode). There are 7 items related to the technology sub-dimension; the highest score can be obtained at 35.00, and the lowest is 7.00. There are 3 items related to the digitalization sub-dimension; the highest score obtained is 15.00, and the lowest score is 3.00. There are 2 items related to the social sub-dimension; the highest score is 10.00, and the lowest is 2.00. There are 3 items related to the lifestyle sub-dimension; the highest score that can be obtained is 15.00, and the lowest score is 3.00. In Table 1, it is seen that there are teachers with both the lowest score and the highest score for each sub-dimension separately. The number of teachers with the lowest and highest scores is 1 person in the technology dimension, and it has been determined that 8 teachers received 29 points in this dimension (mode). It was found that there were 5 teachers with the lowest score and 3 teachers with the highest score in the digitalization dimension, and 10 teachers received 7.00 points (mode) from digitalization. It was determined that there were 7 teachers with the lowest score in the social dimension, 9 teachers with the highest score, and 13 teachers who received 6.00 points from the social dimension (mode). It was found that there were 8 teachers with the lowest score in the lifestyle dimension, 14 teachers with the highest score, and 28 teachers with 14.00 or 15.00 points in the lifestyle dimension.

In the Metaverse scale developed by Süleymanoğulları et al. (2022), intermediate statements from the statement or disagree to the statement agree are not included. While presenting the research findings, the researchers used statements such as partially disagree, indecisive, and partially agree as intermediate expressions as in the field article and included them in the explanations. In the tables, the findings are presented according to the original state of the scale.Items related to the technology sub-dimension of Metaverse were published by Süleymanoğulları et al. (2022) as items 1-2-3-4-5-10-13. The descriptive findings related to the technology sub-dimension are given in Table 2.

Table 2.

Descriptive findings related to the technology sub-dimension

Technology	Disagree f (%)	f (%)	f (%)	f (%)	Agree f (%)
1) The Metaverse is an investment tool.	16 (%22.9)	14 (%20)	**23 (%32.9)**	11 (15.7)	6 (%8.6)
2) The Metaverse is the future of the Internet.	**27 (%38.6)**	16 (%22.9)	7 (%10)	7 (%10)	13 (%18.6)
3) The **Metaverse** contains innovations that will make our lives easier.	**26 (%23.1)**	18 (%25.7)	8 (%11.4)	7 (%10)	11 (%15.7)
4) The Metaverse has a reliable infrastructure.	7 (%10)	8 (%11.4)	**26 (%37.1)**	16 (%22.9)	13 (%18.6)
5) The Metaverse is the most important product of developing technology.	14 (%20)	17 (%24.3)	**21 (%30)**	13(%18.6)	5 (%7.1)
10) The Metaverse is a product of marketing strategy.	18 (% 25.7)	**20 (%28.6)**	18 (%25.7)	7(%10)	7(%10)
13) The Metaverse will affect the level of virtual communication and interaction of people.	**27(%38.6)**	23(%32.9)	2 (%2.9)	7 (%10)	11 (%15.7)

When the answers to the technology dimension are examined in general, it is seen that the disagree answer has the highest rate with 27%. When the response percentages for each item were examined, it was revealed that mathematics teachers were more undecided about the metaverse being an investment tool, having a reliable infrastructure, and being the most important product of developing technology."The Metaverse is the future of the Internet.", The Metaverse embodies innovations that will make our lives easier." and "The Metaverse will affect the level of virtual communication and interaction of people."The articles mentioned in the form mention the advantages of the metaverse, but it is noteworthy that the number of teachers who report that they disagree with these articles is too large. The percentage of teachers' disagreement with the

idea that the Metaverse is a product of the marketing strategy is approximately 54%, along with the percentages that disagree and partially disagree. When the statements of disagreeing and partially disagree are taken together, it is a notable finding that the percentage of responses for each item, except for item 4, is over 42%. At this point, it is seen that secondary school mathematics teachers mostly have negative opinions about the technology dimension, and the percentage of answers as "agree" is low for each item.

Items related to the digitalization sub-dimension of the Metaverse were published by Süleymanoğulları et al. (2022) as items 9, 11, 12. Descriptive findings regarding the sub-dimension of digitization are given in Table 3.

Table 3.

Descriptive findings related to the digitalization sub-dimension

Digitalization	Disagree f (%)	f (%)	f (%)	f (%)	Agree f (%)
9) In the metaverse, I take part in the metaverse world by designing my avatar.	12 (%17.1)	8 (% 11.4)	**21 (%30)**	10 (%14.3)	19 (%27.1)
11) I do virtual shopping in the Metaverse environment	10 (%14.3)	**17 (%24.3)**	16 (%22.9)	13 (%18.6)	14 (%20)
12) I participate in events that will be held in the world of the Metaverse (concert, sports activity, excursion, meeting training, etc.).	10 (%14.3)	**19 (%27.1)**	18 (%25.7)	13 (%18.6)	10 (%14.3)

When the responses given about the digitalization dimension are examined in general, it is seen that the rates of "undecided" and "partially disagree" are high.It is considered that the articles related to the digitalization dimension are related to the forms of participation in the Metaverse world in general. At this point, it has been found that middle school mathematics teachers are most close to the idea of designing their avatars and taking part in the metaverse world.

Items related to the social sub-dimension of the Metaverse were published by Süleymanoğulları et al. (2022) as items 14, 15.The descriptive findings of the social sub-dimension are given in Table 4. **Table 4.**

The Descriptive findings of the social sub-dimension

Social	Disagree f (%)	f (%)	f (%)	f (%)	Agree f (%)
14) The metaverse will negatively affect family ties.	11 (%15.7)	18 (%25.7)	**23 (%32.9)**	8 (%11.4)	10 (%14.3)
15) Metaverse will negatively affect my health (sleep, nutrition, active life, depression, etc.).	18 (%25.7)	18 (%25.7)	**19 (%27.1)**	7 (%10)	8 (%11.4)

The scope of articles on the social sub-dimension draws attention to the negative aspects of the metaverse. In this context, it is seen that the rate of instability is high in each substance. It is a remarkable finding that the proportion of negative opinions about health in the social dimension of the Metaverse has increased above 50%.

The items related to the lifestyle sub-dimension of the Metaverse were determined as 6,7,8 items. The descriptive findings of the lifestyle sub-dimension are given in Table 5.

Table 5.

Descriptive findings of the lifestyle sub-dimension

Lifestyle	Disagree f (%)	f (%)	f (%)	f (%)	Agree f (%)

6) The Metaverse will change our living standards and routines.	22 (%31.4)	**25(%35.7)**	6 (%8.6)	8 (%11.4)	9 (% 2.9)
7) A virtual living environment is being built through the Metaverse.	**30 (%42.9)**	17 (%24.3)	6 (%8.6)	7 (%10)	10 (%14.3)
8) Thanks to the Metaverse, the transition from the physical to the virtual world will accelerate.	**31 (%44.3)**	15 (%21.4)	7 (%10)	5 (%7.1)	12 (%17.1)

When the responses given regarding the lifestyle sub-dimension of the metaverse are examined, it is also seen that teachers generally do not accept life in the metaverse world and have a high rate of responding as "disagree."

The quantitative dimension of the research investigated whether the knowledge, attitude, and awareness scores of secondary school mathematics teachers regarding the concept of Metaverse differed significantly according to gender. For this purpose, the t-test was used for the independent samples included, and the analysis results are given in Table 6.

Table 6.

T-test results for independent samples according to gender variable

Gender	N	$\bar{X}$	Sd	df	t	p
Female	37	51.21	13.91	68	.691	.492
Male	33	48.81	15.10			

As can be seen from Table 6, there is a difference in favor of the female group between the knowledge, attitude, and awareness scores of female and male teachers regarding the concept of the Metaverse.To understand whether this difference is significant, t-test for independent samples was applied , and t =.691 was found. The difference between the scores of both groups is not significant since the p-value calculated at the 95% confidence interval is p= .492 > .05. In other words, there is no significant difference between the knowledge, attitude, and awareness scores of female and male teachers regarding the concept of Metaverse.

4.2. Findings related to the qualitative dimension of the research

The qualitative dimension of the study was primarily asked whether secondary school mathematics teachers researched the metaverse. Two separate questions were asked to the groups according to the yes or no answer they would give to this closed-ended question. Finally, all secondary school teachers participating in the study were asked to explain their views on the availability of the metaverse in mathematics education.

When the qualitative data were analyzed, it was found that secondary school mathematics teachers answered "Yes" by 50% and "No" by 50% to the question of whether they researched the metaverse concept.When the mathematics teachers who answered" no" were asked to explain their reasons for not doing the research, their answers were examined, and the findings in Table 7 were reached.

Table 7.

Findings on the reasons for the lack of research on the concept of the Metaverse

Themes	Codes	f	%
Personal reasons	Hearing about the Metaverse for the first time	11	25.6
	Lack of need	6	13.9
	Lack of knowledge	3	7.0
	Lack of time for research	2	4.7
	Thinking about researching later	1	2.3
	Lack of opportunity to use	1	2.3
Subtotal		**24**	**55.8**
Negative attitudes	Lack of interest	6	14.0
	Dislike spending time in a virtual environment	3	7.0
	Lack of curiosity	2	4.7
	Thinking that the virtual world is tearing people away from real life	1	2.3
	Thinking that it is not necessary	1	2.3
	Lack of trust	1	2.3
Subtotal		**14**	**32.5**
Metaverse-related causes	Being in the development stage/quite new	3	7.0
	The Metaverse is in English	1	2.3
Subtotal		4	9.3
Resource Shortage	Insufficient Turkish resources	**1**	**2.3**
Total		**43**	**100**

When the reasons for secondary school mathematics teachers not researching Metaverse were examined, 43 opinions emerged. The number of codes increased to more than 35 because some of the 35 teachers who stated that they did not research made statements about more than one code. Opinions were collected under 4 themes: personal reasons, negative attitudes, Metaverse-related causes, and resource shortage. It has been revealed that mathematics teachers do not research the metaverse due to personal reasons 56% and negative attitudes 33%. It is a remarkable finding that 11 teachers stated that they heard about the Metaverse for the first time with this study. Other reasons are that there is no need to investigate the Metaverse in this direction and that it is not interesting. The opinions of T36, T39, and T54 were directly quoted as examples of the teachers' opinions about the reasons for not researching the Metaverse.

T36. *"I prefer to be in everyday life than in virtual environments."*

T39.*"I was interested but did not have time to research it."*

T54. *"Getting things done through the mind, without physical effort, does not give me confidence."*

It was investigated what information the mathematics teachers who stated that they had researched the Metaverse beforehand had about the Metaverse. When the data obtained were examined, the mathematics teachers' perceptions about the metaverse concept emerged, and the findings are presented in Table 8.

Table 8.

Perceptions related to the concept of Metaverse

Themes	Codes	f	%
The technology component of the Metaverse	A virtual world where everything is possible	22	28.9
	Compliance with the requirements of the future/era	10	13.2
	Augmented reality	2	2.6
Subtotal		**34**	**44.7**
The affordancescomponent of the Metaverse	Virtual meetings and artistic activities	5	6.6
	Creating an identity	2	2.63
	Spending your time in the metaverse	2	2.63
	Distances lose their meaning	2	2.63
	Virtual tourism	2	2.63

	The possibility of socialization	2	2.63
	Elimination of obstacles	1	1.32
	Providing alternative experiences to real experiences	1	1.32
Subtotal		**17**	**22.4**
Investment use	Purchase of land and goods	3	3.95
	Digital currency platform	2	2.63
	In the world of marketing	2	2.63
	Big companies invest in the Metaverse	2	2.63
Subtotal		**9**	**11.8**
Educational use	Creating educational environments	7	9.2
	The necessity of providing in-service training to teachers	1	1.3
Subtotal		**8**	**10.5**
Negative attitude	Finding it spooky	2	2.7
	Dislike	1	1.3
	Lack of need	1	1.3
	Not being comfortable with	1	1.3
Subtotal		**5**	**6.6**
Challenge	It can lead to health problems	2	2.6
	It can affect family relationships	1	1.3
Subtotal		**3**	**3.9**
Total		**76**	**100**

When the opinions of 35 secondary school mathematics teachers who stated that they were researching the metaverse were examined, 76 opinions emerged.More than 35 opinions have arisen because some teachers make statements about more than one code. Opinions were collected under 6 themes: technology component of the metaverse, affordances component of the metaverse, investment use, educational use, negative attitude, and difficulties component. When naming the themes, the titles and contents in Figure 1 presented by Mystakidis (2022) were used. When mathematics teachers' perceptions regarding the metaverse concept were examined, it was revealed that 44.7% of them expressed their opinions in line with the technology component of the metaverse and 22.4% of them expressed their opinions in line with the affordances component of the metaverse. It has been determined that the opinion rates regarding the use of Metaverse for investment and its use for educational purposes are close to each other. It is also understood that the perceptions of mathematics teachers who report that they have researched the concept of the Metaverse are generally positive. The proportion of those who express an opinion about the negative attitude and the challenges of the Metaverse is low. The opinions of T1, T66, T8, T10, and T40 were directly quoted to be an example of the perceptions of the teachers who reported researching the concept of the Metaverse.

T1. *"Today, it will allow meetings for art, entertainment, and business purposes in the digital world. Currently, many concerts and performances are already organized."*

T66. *"It provides the opportunity to see places that cannot be visited or seen."*

T8. *"Since everything can be done with minimal movement, serious health problems can arise, especially obesity."*

T10. *"It can provide unlimited transportation to the whole world."*

T40. *"Currently, most people use the Internet. 40 or 50 years ago, the Internet was a utopia; now, it is the truth of life. The Metaverse is in the same situation right now. For now, utopia is the reality of the future."*

Finally, the opinions of mathematics teachers about the usability of Metaverse in mathematics education were investigated in the qualitative part of the research. The qualitative data were collected under positive opinions, lack of knowledge, and negative opinions. Table 9 contains findings on positive opinions about the availability of metaverse in mathematics education, while Table 10 contains findings on the themes of lack of knowledge and negative opinions.

Table 9.

Sub-themes and findings related to the theme of positive opinions on the availability of the Metaverse

Sub-themes	Codes	f	%
Contributions to mathematics learning	In concretization	17	19.3
	In Geometry topics (3dimensional perception)	9	10.2
	In order to facilitate the lecture	5	5.68
	Attracting interest to the lesson	2	2.27
	In increasing permanent learning	2	2.27
	In relating mathematics with everyday life	2	2.27
	In internalizing mathematics more comfortably	1	1.136
	Enabling learning by doing	1	1.136
	Improving mathematics achievement	1	1.136
	Increasing participation in the course	1	1.136
	To gain problem-solving skills	1	1.136
	Providing easy access to information	1	1.136
	In developing the ability to reason	1	1.136
	In developing the attribution skill	1	1.136
	In changing attitudes towards mathematics in a positive way	1	1.136
	To repeat the lesson	1	1.136
	At each grade level	1	1.136
Subtotal		**48**	**54.5**
Positive attitudes	Useful	10	11.4
	Necessary	5	5.7
	Enjoyable	1	1.1
Subtotal		**16**	**18.2**
Prerequisites for its use	When technological infrastructure and content are created	4	4.5
	Need for in-service training	3	3.4
	Need for further research	2	2.3
	Need for being open to innovations	2	2.3
	Possible in virtual classrooms	2	2.3
	Possible in the future	2	2.3
	The idea that each country should build/invest in its mathematical universe	1	1.1
Subtotal		**16**	**18.2**
Perceptions related to the concept of the metaverse	VR (everything is possible)	5	5.7
	İnnovator	2	2.3
	Simulation	1	1.1
Subtotal		**8**	**9.1**
Total		**88**	**100**

When the opinions of secondary school mathematics teachers about the usability of Metaverse in mathematics education were examined, the 102 opinions obtained were collected under 3 themes. Of the 102 opinions, 88 were expressed on the themes of positive opinions, 9 were expressed as lack of knowledge, and 5 were expressed as negative. The number of codes has increased to more than 70 because some of the 70 mathematics teachers who participated in the study made statements about more than one code. It was determined that 88 of the 102 opinions were obtained; that is, 86% of them reported positive opinions. Since positive opinions on the availability of the Metaverse in mathematics education provide a rich and diverse set of data, the theme of positive opinions is divided into sub-themes. Positive opinions, contributions to mathematics learning, positive themes, prerequisites for use, and perceptions were examined under 4 sub-themes. Accordingly, it was revealed that 54.5% of the positive opinions about the use of metaverse in mathematics education were in the direction of contributions to mathematics learning. The ratio of opinions that draw attention to positive attitudes and those that provide prerequisites for using the metaverse are the same and were found to be 18.2%. The lowest proportion of positive opinions is perceptions about the metaverse concept. The low percentage of perceptions about the concept of the Metaverse can be explained by the fact that positive opinions about the concept of the Metaverse are

generally collected under the theme of contributions to mathematics learning and positive attitudes. In order to be an example of the positive opinions of teachers about the availability of the Metaverse, the opinions of T2, T27, T33, T45, T46, and T70 were cited directly.

T2. *"I think it will be very useful, especially for geometry. It will help students with issues that need to be considered in 3D."*

T27. *"The virtual world can be very useful for students to embody difficult-to-understand topics."*

T33. *"I think it would be the easiest way to concretize such an abstract lesson as mathematics. I think it can be applied differently at every grade level, such as elementary, middle, and high school."*

T45. "*Practicing mathematics in the virtual universe, modeling will interest students, and we will get more permanent learning."*

T46. *"Virtual meetings may come up with virtual classes, perhaps in the distant future."*

T70. *"Countries should especially establish their mathematical universe. Investments in the Metaverse should be made within the state in the field of education, and teachers should be encouraged to produce in this virtual universe."*

Table 10.

Findings on the themes of lack of knowledge about the availability of the Metaverse and negative opinions

Themes	Codes	f	%
Lack of knowledge	I do not have an idea/I do not know	5	35.7
	No opinion	4	28.6
Subtotal		**9**	**64.3**
Negative opinions	Not finding it realistic	2	14.28
	Conditions of the region in which the teacher works	1	7.14
	Not finding it healthy	1	7.14
	Unfitness for primary-secondary school students	1	7.14
Subtotal		**5**	**35.7**
Total		**14**	**100**

14 opinions draw attention to the lack of knowledge about the usability of Metaverse in mathematics education or its negative aspects. This represents a rate of 14% out of 102 opinions. When the negative opinions of teachers are examined, it is seen that they draw attention to the difficulties component in figure 1 presented by Mystakidis (2022). The situations observed by the mathematics teachers working in different regions of Türkiye participating in the research in their classrooms, the readiness of the students, the physical conditions of the schools, the socio-economic situation of the region where the school is located, and the differentiation of the perspectives on education can be effective in the emergence of negative opinions.This is also evident from the prerequisites and explanations teachers offer for effective use of the metaverse in mathematics education (see Table 9). The opinions of T14, T42, T53, and T67 were directly quoted to be an example of the themes of teachers' lack of knowledge about the availability of the Metaverse and negative opinions.

T14. *"Perhaps it may be suitable for advanced learning ages; it is not suitable for primary education level."*

T42. *"In the region where I work, students find it difficult to get to school. Studying metaverse mathematics sounds very absurd."*

T53. *"I find it healthier to have a face-to-face math education."*

T67. *"I do not think it can be used effectively based on our knowledge and material conditions."*

5. Conclusion, Discussion, and Recommendations

The metaverse concept, which entered our lives with a science fiction novel, is now beginning to become a concrete concept in our increasingly digitalized world.With digital games, online distance learning, virtual currencies, NFTs, clothes produced for avatars and avatars, and experiences thanks to three-dimensional environments, the virtual world now provides many opportunities for users.The literature predicts that the metaverse will be in almost every sector in the coming years. It is said that the lives of children growing up in the digital age and the virtual world are intertwined. When the literature is examined, it is seen that using metaverse technologies in educational settings increases student achievement, positive attitude towards courses, motivation, concretization, and permanent learning. Based on this, it is recommended that Metaverse technologies be integrated into educational environments. In this regard, the need to investigate teachers' knowledge, attitudes, and awareness about the concept and components of the metaverse has arisen. In this study, conducted with mathematics teachers who perform their duties in different regions of Türkiye, teachers' opinions also shed light on the future of their students studying in different regions and under different conditions. In this sense, it is possible to say that the study is the first in the summer field. The study's data were collected quantitatively and by methods, and the data diversification path was taken. When the opinions of secondary school mathematics teachers about the concept of the metaverse in mathematics education were examined;

1. Teachers' opinions about the availability of the Metaverse in mathematics education are generally positive, and they indicate that it can be used mainly for concretization, geometry and they find it useful,
2. Perceptions about the concept of the Metaverse are themed as the possibilities component, technology component, difficulties component, negative attitude, investment use, educational use, and explanations are made mostly about the technology component of the Metaverse,
3. The reasons for the lack of research on the concept of the Metaverse are themed as personal reasons, negative attitudes, Metaverse-related causes, and lack of resources, and explanations are made mostly for personal reasons,
4. Knowledge, attitudes, and awareness scores regarding the concept of metaverse do not differ significantly by gender; female and male mathematics teachers have similar views,
5. The opinions of mathematics teachers about the concept of the Metaverse, where knowledge, attitude, and awareness scores for each dimension are generally between undecided and disagree options,
6. The overall average of the technology, lifestyle, digitalization, and social sub-dimensions is 50, and the average scores of the technology-related sub-dimensions are higher,
7. It has been concluded that the ratio of whether teachers research the concept of the metaverse is 50% yes and 50% no.

In our study, it was investigated whether the teachers had heard of the concept of Metaverse before and it was found that the answers had equal percentages as "yes" and "no". In the study conducted by Statista (2022), it was seen that the rating was broader rather than yes-no. In this context, as of January 2022, it was determined that 14% of adults in the United States of America have very good metaverse information; 24% have some knowledge; 31% had heard of the concept of Metaverse but did not know what it was, and 31% had never heard of the term metaverse before.

It is seen that the results obtained from this study support the results of previous studies in the literature. It has been observed that the opinions on the theme"Contributions to mathematics learning" and the studies in the literature support each other.In the literature,studies are showing that success increased in mathematics courses where Metaverse technologies were used (Mutluoğlu & Erdoğan, 2021; Altıok, 2020;

Özdemir & Özçakır, 2019; Şimşek et al., 2019), and students' attitudes towards mathematics (Özdemir & Özçakır, 2019) and geometry have changed positively (Mutluoğlu & Erdoğan, 2021), and that metaverse have positive effects on mathematics teaching-learning processes (Cabero-Almenara et al., 2021).It has been stated that integrating Metaverse into educational environments makes learning fun, engaging, and useful; increases the motivation of those who attend the course, and saves the course from mediocrity (Altıok, 2020; Çetin, 2019; Durak & Karaoğlan Yılmaz, 2019; Şimşek et al., 2019;İlic, 2013). Studies in the course show that using Metaverse technologies embodies abstract concepts, increases persistence (Lee et al., 2022; Boz & Özerbaş, 2020), frees the course from mediocrity, and increases self-efficacy of the participants (Şahin, 2016). Studies indicate that using Metaverse technologies in mathematics and other courses facilitates learning, increases performance, and is beneficial (Altıok, 2020; Durak & Karaoğlan Yılmaz, 2019; Somyürek, 2014). In the literature, there are studies showing that men are more interested in the concept of Metaverse than women (for example, Aburbeian et al. (2022); Newzoo (2022); Savaş, Karababa & Turan (2022)), as well as studies showing the opposite of this situation (for example; Boz (2019)) In our study, it was concluded that gender was not an effective variable on the scores obtained from the metaverse scale.

In this study, it was investigated what information mathematics teachers who conduct research have on the Metaverse.It has been observed that the themes of"investment use"and"educational use" are similar to the literature studies.It is stated in the literature that Metaverse focuses on education and digital marketing (Damar, 2021); Metaverse is seen as an investment tool, virtual lands are perceived as an investment opportunity (Kuş, 2021), and users buy land and digital artifacts there is a possibility of taxation of transactions made with digital currencies (Şahin Orkunoğlu & Çiftçi, 2022).

The literature has stated that interpersonal communication processes and all types of relationships will be perceived as if they are happening in the real world (Türk et al., 2022). This result parallels the view of the "virtual world where everything is possible."

The literature states that participation in the Metaverse will be thanks to avatars (Diaz et al., 2020; Suh & Ahn, 2022). Türk et al. (2022) state that in the future, users will create an identity to feel valued, gain social status, be approved, and feel belonging. This result is in parallel with the code "Creating an identity."

The expectation that the Metaverse will be present in all areas of our lives in the next 15-20 years (Damar, 2021) supports the teachers' "in the future" view about the availability of the metaverse in mathematics education.

It is possible to say that the codes stated by the teachers on the theme of "negative opinions" support the work in the field of literature.There are studies showing concerns about economic difficulties in obtaining the tools to connect to the Metaverse, internet connection problems, students' hesitations to use technology, the perception that they will be disconnected from the real world, the fear of restriction of freedom or potential health problems (Altiok, 2020; Durak & Karaoğlan Yılmaz, 2019; Kuş, 2021).Şahin Orkunoğlu & Çiftçi (2020) emphasize the necessity of transitioning to 5G internet infrastructures and providing cyber security infrastructures in our country as soon as possible.

Altiok (2020) designed and implemented an augmented reality-supported learning environment for elementary school students in his study.As a result of the research, it was stated that there are generally positive results and negative results, so students have reservations about using the technology and cannot use the device. In this regard, it can be said that it contradicts the code "Not suitable for primary-secondary school students."

Based on the results of this study;

1. It may be suggested to conduct a study in which the opinions of Elementary School-Middle School-High School students and teachers about the concept of the Metaverse are taken and compared.

2. Mathematics teachers can increase their knowledge, attitudes, and awareness by providing in-service training about the Metaverse.
3. By adding courses about the Metaverse to the undergraduate programs of educational faculties, pre-service teachers can be trained.
4. Considering that the Metaverse will enter our lives in many areas, including education, it may soon be recommended to speed up the process of preparing and integrating the necessary infrastructure and equipment nationally.

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