Journal of Educational Research and Evaluation
Volume 8, Issue 4, 2024, pp. 718-730
P-ISSN: 2597-422x E-ISSN: 2549-2675
Open Access: https://doi.org/10.23887/jere.v8i4.82238

The Impact of Using Metaverse Technology in the Learning Process in Junior High Schools

Usfandi Haryaka[1*], Warman[2]

[1,2] Fakultas Keguruan dan Ilmu pendidikan, Universitas Mulawarman, Samarinda, Indonesia

ARTICLE INFO

Article history:
Received July 07, 2024
Accepted October 23, 2024
Available online November 25, 2024

Kata Kunci :
Bantuan Belajaran, Guru, Siswa, Teknologi Metaverse, Sekolah Menengah

Keywords:
Learning Assistance, Teachers, Students, Metaverse Technology, High School

ABSTRAK

Dalam dunia pendidikan saat ini, teknologi pendidikan diintegrasikan dengan Metaverse. Namun pada kenyataannya masih banyak sekolah yang belum memanfaatkan Metaverse dalam proses pembelajaran. Secara teori, dengan bantuan Metaverse dapat meningkatkan minat belajar. Namun pada kenyataannya, hasil belajar siswa pada mata pelajaran matematika, IPA dan IPS yang diperoleh siswa justru rendah. Hal tersebut mendesak untuk dikaji dengan adanya kesenjangan antara teori dengan fakta di lapangan, dengan tujuan untuk menganalisis sejauh mana teknologi Metaverse digunakan dalam proses pembelajaran di kelas, khususnya pada proses pembelajaran matematika, IPA dan IPS di SMP. Metode penelitian yang digunakan adalah kuantitatif dengan menggunakan surbei angket. Sampel penelitian sebanyak 360 orang guru yang tersebar di Samarinda. Pemilihan sampel dilakukan secara acak kepada guru yang telah menggunakan Metaverse sebagai alat bantu dalam proses pembelajaran. Teknik pengumpulan data dengan angket. Skala penilaian dari poin 1 sampai dengan poin 5. Teknik analisis dengan statistik deskriptif dibantu SPSS Versi 25.0 dengan menghitung mean, presentase, simpangan baku dan simpangan baku. Hasilnya, guru terbukti cakap dalam menggunakan teknologi Metaverse dalam pengajaran matematika sains dan studi sosial. Ditemukan bahwa teknologi Metaverse telah terintegrasi secara efektif ke dalam metode pengajaran guru dan guru memberikan pengalaman belajar yang lebih baik kepada siswa. Kesimpulannya adalah bahwa ada perbedaan yang signifikan antara sikap guru mengenai tingkat penggunaan teknologi Metaverse. Namun, tidak ada perbedaan signifikan yang diamati berdasarkan pengalaman guru dalam pembelajaran.

ABSTRACT

In today's world of education, educational technology is integrated with Metaverse. However, in reality, there are still many schools that have not utilized Metaverse in the learning process. In theory, with the help of Metaverse, it can increase interest in learning. However, in reality, student learning outcomes in mathematics, science and social studies, science and social studies subjects obtained by students are actually low. This urgently needs to be studied with the gap between theory and facts in the field, with the aim of analyzing the extent to which Metaverse technology is used in the learning process in the classroom, especially in the learning process of mathematics, science and social studies, science and social studies in junior high schools. The research method used is quantitative using a questionnaire survey. The research sample was 360 teachers spread across Samarinda. The sample selection was carried out randomly to teachers who had used Metaverse as a tool in the learning process. Data collection techniques with questionnaires. Assessment scale from point 1 to point 5. Analysis techniques with descriptive statistics assisted by SPSS Version 25.0 by calculating the mean, percentage, standard deviation and standard deviation. As a result, teachers proved to be proficient in using Metaverse technology in teaching mathematics, science and social studies, science and social studies. It was found that Metaverse technology has been effectively integrated into teachers' teaching methods and teachers provide better learning experiences to students. The conclusion is that there is a significant difference between teachers' attitudes regarding the level of use of Metaverse technology. However, no significant difference was observed based on teachers' experiences in learning.

*Corresponding author.
E-mail addresses: usfandi.haryaka@fkip.unmul.ac.id (Usfandi Haryaka)

1. INTRODUCTION

In the 21st century, the use of technology is increasingly widespread in various fields, especially in education. So, it has become a very basic need in everyday communication (Srivastava et al., 2020; Fedorov & Mikhaleva, 2020). In the field of education, technology greatly influences user access to information and communication methods in conveying information outside of school hours.. Additionally, unforeseen circumstances such as the Covid-19 outbreak, external conflicts, natural disasters, and severe weather require teachers, parents, and students to take advantage of the benefits that technology provides (Bell et al., 2024; Atlam et al., 2022). In this case, the emergence of the metaverse can be said to be a logical consequence of the extraordinary progress in the world of digitalization and communication in modern times. The influence of the media used extends to various fields and aspects of everyday human life (Alizadehsalehi et al., 2020; Haltas et al., 2021). Additionally, the widespread use of metaverses on social media platforms has grown significantly, from a concept that was initially taken for granted to now an undeniable reality (Pellegrino et al., 2023; Golf-Papez et al., 2022). To address emergencies such as the Covid-19 pandemic and the need to support distance learning processes, the education sector has undergone a large-scale integrated transformation (Mishra et al., 2020; Mustafa et al., 2021). Metaverse technology includes many immersive elements such as virtual reality (VR), augmented reality (AR), mixed reality (MR), and 3D environments, as well as real-time interactions and seamless integration with artificial intelligence (AI). This technology facilitates the sharing of experiences among an unlimited number of users worldwide, providing a truly immersive environment that reflects the real environment. This allows users to engage in virtual communication regarding facts in an environment that closely resembles reality (Barreda-Ángeles & Hartmann, 2022; Scurati et al., 2021). Metaverse is a modern technology where users interact and collaborate in a virtual environment, seamlessly integrating virtual reality, augmented reality and 3D space. These immersive platforms not only facilitate direct engagement, but also provide a fun and enjoyable communication experience in a real environment, providing users with feelings of joy, awe and satisfaction (Reer et al., 2022; Scorolli et al., 2023) .

The use of Metaverse provides a rich platform for gaining practical experience, bridging the gap between knowledge and implementation in the field, and facilitating the development of students' cognitive and innovative processes (AlGerafi et al., 2023; Beck et al., 2023). However, facts on the ground show that the lack of interest of teachers and students in using Metaverse in learning makes the expected learning process less effective. Metaverse assistance helps teachers facilitate the development of student independence in the mathematics, science and social studies learning process (Tlili et al., 2022; AlGerafi et al., 2023). In addition to software simulation of metaverse components, a variety of tools can be used, including virtual hundreds of cards, virtual part templates, Deniz parts, virtual calculation parts, Geoboard, and more. These tools provide an interactive platform in the metaverse that facilitates mathematical learning and exploration. However, facts on the ground show that there are still many teachers and students who are skeptical about using Metaverse. The second fact is that in educational institutions the use of Metaverse is still minimal and has not been utilized optimally. Therefore, this research provides an important innovation in exploring the potential of Metaverse technology to increase students' interest in learning at the elementary school level. This research highlights the importance of integrating Metaverse technology into the learning process to create a more engaging and effective learning experience for students. The results show that teachers and gifted students can learn and significantly use Metaverse technology in the context of mathematics, science and social studies education, providing a better learning experience.

Many Metaverse platforms have been developed so far, such as Second Life, Open Simulator, Minecraft, Fortnite, Roblox, Sandbox and Decentral (Tirachini et al., 2020; Yu, 2019). The application of Metaverse technology in education is growing rapidly thanks to features that engage students and enable teachers to provide open learning opportunities and attract learning interest. This provides distance learning while maintaining a feeling of comfort and freedom from pressure (Selvaraj et al., 2021; Bruggeman et al., 2022). Second, in the field of scientific content, Metaverse technology presents scientific material in an interesting way and attracts students' interest. Metaverse technology also simplifies the presentation of complex scientific materials and samples, creating a safe environment that protects students from potential harm. Additionally, Metaverse technology allows students to immerse themselves in virtual worlds that resemble the real world. This immersive experience provides a technological environment where students can realistically observe and explore learning materials (Lumbantoruan, 2022; Kuhail et al., 2022). The virtual classroom environment encourages a fun atmosphere, thereby increasing the level of student engagement, especially in the area of mathematics, science and social studies (JH Lumbantoruan & Manalu, 2024; JH Lumbantoruan & Ditasona, 2024).

As a result, virtual math, science, and social studies lessons have emerged as a necessary tool to increase students' motivation in math, science, and social studies, help them remember facts and concepts, and improve problem-solving skills. The American Council of Teachers of Mathematics, science and social studies, Science, and Social Studies recommends the above approach (Álvarez et al., 2020). Therefore, it is essential to use more effective teaching tools to understand mathematics, science and social studies education and provide students with a solid foundation, allowing them to understand its importance and value. In this way, mathematics, science and social studies, science and social studies can be transformed from abstract subjects into accessible and enjoyable fields, in line with students' realities. Many studies have reinforced the importance of Metaverse technology and virtual mathematics, science and social studies, science and social studies laboratories in mathematics, science and social studies, science and social studies education, especially through the application of hand sensors, simulations, and educational technology. Metaverse technology is a microcosm of real life, bridging the gap between real experiences and abstract concepts (Bibri&Jagatheesaperumal, 2023; Pizzolante et al., 2023; De Felice et al., 2023). By integrating mathematics, science and social studies, science and social studies lessons, the quality and sustainability of learning are improved, providing long-term impacts on students. This is one of the main goals of mathematics, science and social studies education. Many researchers have highlighted the many benefits associated with the use of Math, Science and Social Studies Metaverse, including improved conceptual understanding (Pahmi et al., 2023; Fütterer et al., 2022). Subjects such as mathematics, science and social studies, science and social studies require Metaverse to help students develop a deep conceptual understanding of mathematical concepts, the reality of science and social studies lessons and encourage various thinking skills.

It is urgent to conduct research on teachers who have implemented metaverse technology in the learning process. Because there is a gap between theory, expectations and reality in the field. The theory says that by using metaverse in the learning process with the hope that student understanding and learning outcomes will increase. However, in reality, student understanding and learning outcomes are still low. Seeing the urgency and importance of Metaverse technology including Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR), 3D environments and Artificial Intelligence (AI) in the development of education and its use by researchers in the fields of mathematics, science and social studies, science and social studies education as well. So there needs to be research that examines the use of metaverse technology in the learning process in schools. so that the purpose of this study is to analyze the extent to which Metaverse technology is used in the learning process in the classroom, especially in the learning process of mathematics, science and social studies, science and social studies at the junior high school level.

2. METHODS

The method in this research uses a quantitative approach, namely studying phenomena in a natural context and describing them comprehensively with the help of a questionnaire (Fàbregues et al., 2023; Baas et al., 2020). The research sample consisted of 360 teachers spread across the city of Samarinda-Indonesia. The sample selection was carried out randomly to all teachers who teach in junior high schools and have used Metaverse Technology as an aid during the learning process of Mathematics, science and social studies, Science and Social Studies. The teachers who were respondents in this study had been asked by the researcher and given permission by the principals to become respondents in this study. This study lasted for 6 months, starting from January to June 2024 in junior high schools in Samarinda city. Data collection techniques using surveys with questionnaires. Questionnaires are used to obtain reliable information and obtain reliable data. The questionnaire has been validated by experts and declared valid and reliable. The survey was created using the research indicators in table 1. This survey was developed with the help of sub-tools and to ensure that the reality achieved through advanced technology in junior high schools has been met. The questionnaire in this study consisted of 25 items. The questionnaire was given to respondents with a 1 to 5 point assessment scale. Table 1 below shows the research indicators that are the basis for compiling the Questionnaire.

Table 1. Research Indicators and Distribution of Research Samples

No.	Indicator	Sample
1	Haven't taken any courses yet	88
2	Attend education	89
3	He took two courses	90
4	Participate in more than two training courses	93
	Total Sample	**360**

(Charondo et al., 2023)

Data analysis techniques with descriptive statistics assisted by SPSS Version 25.0 Sakaria et al., (2023), by calculating the mean, percentage, standard deviation and standard deviation. While the questionnaire items were tested for validity and reliability using the Rasch model (Campos et al., 2020) . The reliability criterion for accepting an item exceeds 0.50, indicating that the reliability of the item is acceptable. The acceptable cutoff value is set at a minimum of 2, indicating adequate discrimination between individuals (Goode et al., 2020; Feng et al., 2020) . A five-category scale was used for the use of Metaverse devices in mathematics, science and social studies, science, and social studies, with the following categories: 1 = never used, 2 = rarely, 3 = sometimes, 4 = almost all the time, and 5 = very often used. The structure of the observation section shows the participants' responses based on the rating scale. The observed mean values illustrate the expected response pattern following a fairly normal pattern with a systematic progression from negative to positive, as shown. To ensure reliability using the Rasch model, it is important to evaluate person reliability and item reliability. The reliability standard must exceed 50% to be considered satisfactory. In addition, the person-object separation value must exceed 2 to be considered acceptable, as shown by previous studies (Herrera-Franco et al., 2020; Mousa & Othman, 2020). In this study, the reliability of the scale was evaluated by measuring the reliability of the person and item. The results of the research test showed that the scale showed an appropriate level of reliability for its items. From the results of the instrument validation test, the number of respondents reaching n = 64 was declared validated with $\alpha = 0.05$ (one-sided), effect size = 0.15 (moderate) and the actual strength of the questionnaire instrument (moderate). The actual level value or inferential statistical test 1 - β) is 0.95. The instrument used in this study has been assessed as valid, naturally consistent, suitable for use as research measuring instrument, suitable for distribution to be used as an evaluation measuring instrument in this study, and suitable for evaluating respondents.

3. RESULT AND DISCUSSION

Results

The results of this study found from the evaluation results the extent to which teachers use Metaverse technology in teaching mathematics, science and social studies, science and social studies lessons, the responses of the research sample totaling 360 teachers can be seen in the results of the mean, frequency, percentage, standard deviation, and values calculated based on these responses in Table 2.

Table 2. Research Sample Responses Regarding the Level of Use of Metaverse Technology

Goods	Means	Standard Deviation	Rank
Teachers are actively involved in creating metaverse content for. The subject of mathematics, science and social studies is taught or tutored	3.39	1.523	6
Teachers use Metaverse technology to track and assess students. Progress in mathematics, science and social studies	3.35	1.551	7
Master is constantly using metaverse technology all the time. Teaches mathematics, science and social studies courses	3.31	1.426	8
Teachers' use of metaverse technology facilitates the exchange process. Experience between colleagues	3.59	1.589	3
The mathematics, science and social studies teacher collaborates with his colleagues in the construction field. Metaverse reality content, allowing a shared knowledge base to grow	3.42	1.464	5
By using Metaverse technology, teachers can save time and energy. Efforts to communicate knowledge effectively	3.56	1.666	4
When using Metaverse reality technology, students are actively engaged. Interactive sessions with teachers	3.61	1.694	2
Integrating metaverse technology contributes to professionalism. Mathematics, science and social studies teacher development	3.68	1.704	1
General Average	**3.49**	**1.509**	
First dimension: The extent to which teachers use Metaverse technology in teaching mathematics, science and social studies			
I use Diene's virtual work to teach math concepts (especially numbers and operations) for students	4.0	1.049	3
I use virtual link cubes to teach math concepts to students (Addition, Subtraction and Classification)	3.9	1.118	7

Goods	Means	Standard Deviation	Rank
I use virtual domino subtraction facts as a teaching tool to help students. Understand the concept of subtraction	3.63	1.237	9
I use a virtual number line as a teaching tool to teach students. Number of concepts	3.97	1.166	5
I also use virtual fraction images to teach students the concept of fractions. When they have surgery	3.97	1.172	6
I use a virtual arithmetic scale as a teaching tool to teach students. Concept of mathematical operations	3.45	1.349	10
I use a virtual clock model to teach timekeeping skills to students	4.02	1.133	2
I use virtual geometry tools to teach students the art of drawing. Engineering design	4.08	1.055	1
I use standard drawing applications such as GeoGebra and Desmos. Educational tool to teach students skills in drawing geometric shapes	3.37	1.448	12
I use virtual geometry pieces to teach students about geometric shapes. And a spatial reasoning unit	3.88	1.168	8
I use virtual geometric models to teach students. Geometric shape unit.	3.98	1.135	4
I use virtual calculators to enhance students' learning experience. Calculate the area of the circle	3.35	1.390	13
I use a virtual geoboard as a teaching tool to teach students how to do this. Drawing geometric shapes	3.41	1.399	11
General Average	**3.77**	**0.3839**	**-**
Second dimension: The extent to which teachers use Metaverse technology in teaching mathematics, science and social studies			

Analysis of Table 2 shows that teachers' use of Metaverse technology in mathematics, science and social studies teaching, according to supervisors' and teachers' own perceptions, is relatively high. The overall average score was 3.49 out of 5, indicating that the average was in the fourth category (3.41-4.22) on a five-point scale. This average corresponds to category four on a five-point scale, which represents "almost every time used" according to the research tool. A standard deviation of 1.509 indicates that there is a level of consensus among teachers and supervisors regarding the extent to which teachers use Metaverse technology in teaching mathematics, science and social studies. Most of the items received high scores, except items 1, 2, and 3 which received medium scores. This small difference in opinion reflects differences in the sample's views on a particular matter. The overall average score of 3.77 out of 5 corresponds to category four on the five-point scale, i.e. "used almost all the time" according to the research tool. Based on the sample responses, the most salient items regarding the extent to which teachers use Metaverse technology in mathematics, science and social studies teaching are structured as follows: Item 8, Item 7, and Item 1, in descending order as agreed. Regarding the lowest scoring items regarding teachers' use of Metaverse techniques in mathematics, science and social studies teaching, they were arranged as items 12, 9, and 13 in descending order. To answer the second question, which tested whether there were statistically significant differences between supervisors' and teachers' views regarding the use of Metaverse technology in mathematics, science and social studies teaching at primary level based on academic qualifications, experience and education, statistical analysis was carried out. including not testing. One-way analysis of variance (ANOVA) was performed. Table 3 shows the t-test results showing the extent to which teachers use Metaverse technology in teaching mathematics, science and social studies at the elementary level from the perspective of supervisors and teachers, divided by academic qualifications, experience and education. The level of use of Metaverse technology by teachers in teaching mathematics, science and social studies, as seen by supervisors and teachers themselves, is very high are presented in Table 3.

Table 3. Mean Value, Standard Deviation and T Value

Measurement		N	Means	Deviation	T Value	Signature.
Using Metaverse Technology in Mathematics, science and social studies Education	Bachelor	51	2.55	1.528	2.049	0.056
	Doctoral Student	21	1.88	1.140		
	Bachelor	51	2.58	1.515	2.423	0.101

Measurement		N	Means	Deviation	T Value	Signature.
Using Metaverse Technology in Mathematics, science and social studies Education	Doctoral Student	21	1.81	1.308		
General Average	Bachelor	51	2.57	1.525	2.317	0.068
	Doctoral Student	21	1.87	1.331		

Based on the results presented in Table 3, no statistically significant differences were observed in the mean scores of the sample members regarding the use of Metaverse technology in basic mathematics, science and social studies education based on their academic qualifications. The results of a one-way variance analysis of the degree of availability of active open thinking indicators on the results of gifted programs on the scale dimension, considering the number of programs that gifted students receive are presented in Table 4.

Table 4. Results of Variance Analysis of Differences in Mean Responses

An Exercise	Using Metaverse Technology in Mathematics. science and social studies Education	Between Groups	57893	2	28.946	14.656	000
		In Group Total Number	347.59 405.49	176 178	1975		
	Using Metaverse Technology in Mathematics. science and social studies Education	Between Groups	7.877	3	2.626	3.852	0.010
		Within Groups Total	175.88 183.76	258 261	682		
	Complete Measurements	Between Groups	15.439	3	2.173	3.192	0.010
		In A Comprehensive Group	235.514 139.086	193 199	871		
Skill	Using Metaverse Technology I Teaching Mathematics. science and social studies	Between Group	7.093	2	3.546	1.567	212
		In Group	298.39	176	2.264		
		Total Number	305.49	178			
	Using Metaverse Technology In Mathematics. science and social studies Teaching	Between Groups	3.601	2	1800	4.661	0.110
		Within Groups	222.89	277	386		
		Total Number	226.49	279			
	Complete Measurements	Between Group	3.419	3	1.481	3.126	0.130
		In Group	135.52	96	377		
		total number	139.34	99			

Based on the results presented in Table 4, no statistically significant differences were observed in the mean scores of the sample members regarding the use of Metaverse technology in elementary mathematics, science and social studies teaching based on their experiences. Meanwhile, statistically significant differences emerged in the views of teachers and supervisors regarding the extent of use of Metaverse technology in basic mathematics, science and social studies education. These differences were observed when considering sport variables. To determine the direction of differences in favor of the two categories, the Schefft post-hoc test was used to determine the four-cycle periods obtained in Table 5.

Table 5. Schefft Test Results for Differences in the Number of Subject Teachers Obtained

(i) Courses	(j) Courses	Average Difference (IJ)	Signature.
0 Courses	1 Course	0.23726	659
	2 Courses	0.25884	511

(i) Courses	(j) Courses	Average Difference (IJ)	Signature.
	More than two Courses	0-.15524	722
1 Course	0 Courses	0-.23726	659
	2 Courses	0.02158	914
	More than 2 Programs	0-.39250	0.130
2 Courses	0 Courses	0-.25884	511
	1 Course	0-.02158	914
	More than 2 Programs	0-.41408	0.044
More than two Courses	0 Courses	0.15524	722
	1 Course	0.39250	0.130
	2 Courses	0.41408	0.044

Based on the results presented in Table 5, there is a statistically significant difference between teachers' and supervisors' views on the use of Metaverse technology in elementary mathematics, science and social studies education. These differences emerge when looking at training variables, particularly between individuals who received one course and those who received more than two courses. Specifically, the views of those who received more than two courses were more supportive of the use of Metaverse technology than those who received only one course. The analysis showed that there was no statistically significant difference in the views of teachers and supervisors regarding the extent of use of Metaverse technology in elementary mathematics, science and social studies teaching. These results hold for each remaining pair of training variable categories.

Discussion

The findings of this study are that teachers' use of Metaverse technology in teaching mathematics, science, and social studies at the elementary level is high. The results of this survey can be attributed to teachers' awareness of the added value provided by the development of Metaverse technology in the educational context, as well as their acceptance of the application of new and useful educational technology tools to improve and simplify the teaching process. Metaverse technology provides interactive and immersive learning experiences that engage students. By using simulations, virtual environments, and augmented reality, students can be actively involved in their learning, thereby increasing engagement and motivation. This high level of engagement has been recognized by tutors and teachers as a positive aspect of the use of Metaverse technology in mathematics, science, and social studies classes. Metaverse technology provides visual representations, interactive models, and simulations that support students' conceptual understanding of mathematical concepts. These visual and interactive tools make abstract concepts more concrete and accessible, allowing students to explore and manipulate mathematical ideas in ways that promote deeper understanding.

Tutors and teachers appreciate the potential of Metaverse technology to enhance students' conceptual understanding of mathematics, science, and social studies. Metaverse technology enables personalized learning experiences that are tailored to the needs of each student. Teachers can create customized activities, adaptive assessments, and targeted feedback to meet a variety of learning styles and skill levels. This personalized approach ensures that students receive the support and challenge needed to improve their learning outcomes. The ability of Metaverse technology to facilitate personalized learning is appreciated by tutors and teachers. Metaverse technology aligns with today's students' digital fluency. It reflects their use of technology in everyday life and builds on their familiarity with digital devices. Instructors and teachers recognize the importance of integrating technology into education to meet the needs and expectations of modern learners. Facilitators can provide professional development opportunities and support for teachers in effectively integrating Metaverse technology into their mathematics, science, and social studies instruction. This training and mentoring allow teachers to develop the skills and confidence needed to effectively implement Metaverse technology in the classroom. Supervisors and teachers value continued professional development in using technology to teach students in mathematics, science, and social studies at the middle school level (Guggemos & Seufert, 2021; Seufert et al., 2021; Huang et al., 2022) .

In the development of Metaverse technology, interactive and immersive experiences are provided, allowing students to engage with mathematical concepts in a dynamic and visually stimulating way. This can provide opportunities for hands-on exploration, problem solving, and collaboration, which encourage deeper understanding and retention of mathematical principles. By incorporating Metaverse technology into their teaching methods, teachers can create interactive virtual environments, simulations, and activities that cater to a variety of learning styles and actively encourage student engagement. This can increase student motivation and engagement, ultimately improving learning outcomes in mathematics,

science, and social studies. In addition, positive perceptions of Metaverse technology among supervisors and teachers indicate a willingness and openness to implementing innovative teaching methods. A willingness to explore and integrate new technologies into the classroom reflects a commitment to adapting teaching methods to meet students' changing needs and preferences in the digital age. These findings are consistent with previous research (Al Shareef et al., 2022; Braun-Lewensohn et al., 2019; Gupta et al., 2023; Hassan et al., 2019; Özdemir & Özçakir, 2019; Özdemir, 2022).

Other results revealed that there were statistically significant differences in the views of teachers and supervisors regarding the extent of use of Metaverse technology in elementary mathematics, science and social studies teaching. These differences were observed based on a training variable that prioritized individuals who received more than two courses. The researchers attributed these results to several factors. First, they argue that the higher level of use of Metaverse technology among mathematics, science and social studies education teachers can be attributed to a greater curriculum focus on this technology and its ease of implementation compared to traditional methods of conveying information and exploring mathematical concepts. In addition, the statistically significant differences in opinion between teachers and supervisors regarding the extent of use of Metaverse technology in elementary mathematics, science and social studies teaching, depending on educational variables, may be due to several reasons: First, increased familiarity and comfort: teachers who have received more than two College students will likely enjoy Om Metaverse technology with a higher level of familiarity and comfort in using the technology in their teaching methods. This increased familiarity may lead to more positive perceptions regarding the effectiveness and potential benefits of teaching mathematics, science and social studies. Second, improving pedagogical strategies: Teachers who have received a variety of training in Metaverse technology will likely gain a deeper understanding of its pedagogical implications. Third, be confident in its application: Teachers who have received extensive training on Metaverse technology may feel more confident in implementing it in their classrooms. Fourth, acquire more skills: Teachers who have taken various Metaverse technology courses tend to acquire broader skills in their application. Fifth, peer influence: Teachers with different training may have the opportunity to collaborate and exchange experiences with colleagues who have similar educational backgrounds. Interaction with peers can influence perceptions and encourage positive attitudes towards the use of Metaverse technology in mathematics, science and social studies education. Sixth, technical competency: Teachers who have completed a variety of training have likely developed higher levels of technical competency in using Metaverse technology. Seventh, knowledge transfer: Teachers who have taken more Metaverse technology courses may have more opportunities to participate in professional development activities, participate in workshops, or collaborate with experts in their fields. These results are in accordance with research (Kasneci et al., 2023; Onu et al., 2023; Polas et al., 2022).

It is important to note that these statistically significant differences do not mean that teachers with less education have negative views or have lower abilities. Rather, these differences reflect different levels of exposure, knowledge, and experience in using Metaverse technology, which may influence individual perspectives regarding its application in mathematics, science and social studies education. Each individual's unique background and professional development opportunities contribute to their perspective and understanding of the potential benefits and challenges associated with using Metaverse technology in the classroom. The results also show that there is no statistically significant difference between the experiences of teachers and gifted students. This is because teachers face the same educational conditions when teaching mathematics, science and social studies, whatever their level of experience. Given the inherent complexity of mathematics, science and social studies, this is common among all mathematics, science and social studies teachers. As a result, they face similar challenges and tend to use similar teaching methods and learning techniques to facilitate students' understanding of the course material. These results are consistent with several studies that have been completed (Al-Azawei & Alowayr, 2020; Chen et al., 2020; Lemay et al., 2021; Støle et al., 2020).

This research shows that teachers and students use Metaverse technology effectively in the mathematics, science and social studies learning process at the elementary level. Apart from that, this research also shows the need for education and training for teachers so that they can optimally integrate Metaverse into their teaching methods. The weakness of this research is that it does not analyze the barriers to implementing Metaverse technology in elementary schools. Because, the aim of the research is not to show teacher training carried out by the Ministry of Education regarding the use of metaverse technology in the learning process in elementary schools. This research also has weaknesses, namely that it has not carried out an analytical study of the elementary school curriculum with a focus on adapting it to the developmental needs of elementary school students, and at this stage the researchers have not yet achieved metaverse integration. Technology in the learning process. Recommendations are presented by researchers to increase the use of Metaverse technology in elementary mathematics, science and social studies teaching from the perspective of supervisors and teachers. The following recommendations are suggested: Launch

ongoing professional development initiatives specifically targeting Metaverse technologies. These programs should be designed to encourage effective teacher participation in ongoing training and professional development programs. In this way, teachers can improve their skills, expand their knowledge, and keep up with the latest developments in using Metaverse technology to teach mathematics, science and social studies effectively. To encourage effective integration of Metaverse technology into teaching practices, it is recommended to foster collaborative learning communities between teachers and supervisors.

In this study, several limitations must be considered. First, the study sample may not be broadly representative given its focus on teachers and tutors of gifted undergraduate students. This may limit the generalizability of these results to a wider range of teachers and students at different levels of education. Additionally, characteristics of individuals in the sample may also influence research results, such as previous experience with Metaverse technology or different levels of technical skills. Second, the use of questionnaires as a data collection tool may have weaknesses in terms of respondent subjectivity and honesty. Some respondents may provide answers that are considered more "desirable" than the actual answers, which can affect the validity of the research results. In addition, there is the possibility of bias in the interpretation of data collected through questionnaires, especially if the questions are not well designed or certain assumptions are not met. Third, in the context of ongoing educational technology development, the results of this research may have limitations in terms of novelty and long-term relevance. The metaverse is a rapidly changing field, and what is considered effective today may not be relevant in the future. Therefore, Metaverse-related knowledge and skills need to be continuously updated to remain relevant in a dynamic educational context. Fourth, external factors such as the technological infrastructure available in elementary schools, school support, and availability of resources can also influence the application of Metaverse technology in learning. Accessibility limitations or inadequate support may prevent effective use of the Metaverse in educational contexts. When interpreting the results of this study, it is important to consider these limitations so that the results are not overinterpreted or misinterpreted. Although this research provides valuable insight into the use of Metaverse in elementary school mathematics, science and social studies education, a more comprehensive understanding can be gained by considering these limitations.

Based on the results of research on the use of Metaverse in mathematics, science and social studies learning at elementary school level, several recommendations can be given to increase the effectiveness of using this technology in educational contexts. First, it is recommended to improve training and professional development for teachers regarding the use of the Metaverse in mathematics, science and social studies education. Training programs should be designed to encourage active participation of teachers in ongoing training. By improving teachers' skills and knowledge in using Metaverse technology, it is hoped that they can provide a better and more interesting learning experience for students. Second, it is important to build a collaborative learning community between teachers and supervisors to encourage effective integration of Metaverse technology into teaching practices. Collaboration among educational stakeholders can increase the implementation of Metaverse in K-12 mathematics, science and social studies curricula and facilitate the exchange of ideas and best practices.

Third, there must be strong support from schools and the government to provide adequate technical infrastructure and resources to support the use of Metaverse in learning. Investments in educational technology and continuing education will help create innovative learning environments and enable educators to effectively integrate the Metaverse into the learning process. Fourth, it is important to continue conducting research and evaluation regarding the application of Metaverse in elementary school mathematics, science and social studies learning. Follow-up studies could help identify challenges and opportunities that arise as Metaverse technology develops, as well as provide deeper insight into its impact on student interests and achievement. Fifth, develop innovative and interesting teaching strategies based on the Metaverse to increase student engagement and improve understanding of mathematical concepts. Teachers can take advantage of Metaverse's interactive features to create more engaging learning experiences and motivate students to explore mathematics, science and social studies creatively. By implementing these recommendations, it is hoped that the use of Metaverse in elementary school mathematics, science and social studies learning will be more effective and have a positive impact on the student learning process. Collaboration between various educational stakeholders, investment in teacher professional development, and ongoing research will contribute to creating innovative and relevant learning environments.

4. CONCLUSION

The conclusion of the study is that although Metaverse technology has the potential to increase students' interest in learning, its implementation in the field is still not optimal. Of the 360 teachers who were respondents, it was found that they had been trained and had knowledge about the use of Metaverse, student learning outcomes remained low. This shows a gap between theory and practice, where the use of technology alone is not enough to improve learning outcomes; other factors such as student motivation, parental support, and the learning environment also play an important role. This finding indicates that although the teachers involved in this study have good skills in using Metaverse technology as a teaching aid, the interactive and engaging learning experience offered by this technology has not been fully translated into improved student learning outcomes. The implications of this study are very significant for the development of education in the digital era. Schools need to be more active in adopting new technologies and providing adequate training for teachers. In addition, it is important to create a learning environment that supports the use of technology, including support from parents and the community. This study also shows the need for a more in-depth evaluation of the teaching methods used by teachers and how Metaverse technology can be optimized to achieve better learning outcomes. However, this study has several limitations, including a limited focus on one city, namely Samarinda, which may not represent conditions in other areas. In addition, this study only involved teachers as respondents, without involving students directly to get their perspectives on the use of Metaverse. Another limitation is the duration of the study which only lasted for six months, which may not be enough to see significant changes in student learning outcomes. Therefore, several recommendations can be put forward for future research, which need to be carried out by involving students as respondents to get their views on the use of Metaverse in learning. Schools should improve training for teachers not only in the use of technology, but also in effective teaching methods that can utilize the technology. It is important to conduct longitudinal research to see the long-term impact of the use of Metaverse in education. Collaboration between schools, parents, and the community needs to be improved to create a more supportive learning environment. Thus, although the use of Metaverse technology in education shows great potential, the existing challenges must be addressed through a holistic and collaborative approach.

5. REFERENCES

Al-Azawei, A., & Alowayr, A. (2020). Predicting the intention to use and hedonic motivation for mobile learning: A comparative study in two Middle Eastern countries. *Technology in Society*, *62*. https://doi.org/10.1016/j.techsoc.2020.101325.

Al Shareef, H. J., Al Harbi, A., Alatawi, Y., Aljabri, A., Al-Ghanmi, M. A., Alzahrani, M. S., Algarni, M. A., Khobrani, A., Haseeb, A., Alsenani, F., & Elrggal, M. E. (2022). Evaluate the Effectiveness of Outpatient Parenteral Antimicrobial Therapy (OPAT) Program in Saudi Arabia: A Retrospective Study. *Antibiotics*, *11*(4), 1–8. https://doi.org/10.3390/antibiotics11040441.

AlGerafi, M. A. M., Zhou, Y., Oubibi, M., & Wijaya, T. T. (2023). Unlocking the Potential: A Comprehensive Evaluation of Augmented Reality and Virtual Reality in Education. *Electronics (Switzerland)*, *12*(18), 1-22. https://doi.org/10.3390/electronics12183953.

Alizadehsalehi, S., Hadavi, A., & Huang, J. C. (2020). From BIM to extended reality in AEC industry. *Automation in Construction*, *116*(March), 1-13. https://doi.org/10.1016/j.autcon.2020.103254.

Álvarez, J. A. M., Arnold, E. G., Burroughs, E. A., Fulton, E. W., & Kercher, A. (2020). The design of tasks that address applications to teaching secondary mathematics for use in undergraduate mathematics courses. *Journal of Mathematical Behavior*, *60*(August 2020), 1-18. https://doi.org/10.1016/j.jmathb.2020.100814.

Atlam, E. S., Ewis, A., El-Raouf, M. M. A., Ghoneim, O., & Gad, I. (2022). A new approach in identifying the psychological impact of COVID-19 on university student's academic performance. *Alexandria Engineering Journal*, *61*(7), 5223–5233. https://doi.org/10.1016/j.aej.2021.10.046.

Baas, J., Schotten, M., Plume, A., Côté, G., & Karimi, R. (2020). Scopus as a curated, high-quality bibliometric data source for academic research in quantitative science studies. *Quantitative Science Studies*, *1*(1), 377–386. https://doi.org/10.1162/qss_a_00019.

Barreda-Ángeles, M., & Hartmann, T. (2022). Psychological benefits of using social virtual reality platforms during the covid-19 pandemic: The role of social and spatial presence. *Computers in Human Behavior*, *127*(December 2020), 1-13. https://doi.org/10.1016/j.chb.2021.107047.

Beck, D., Morgado, L., & O'Shea, P. (2023). Educational Practices and Strategies with Immersive Learning Environments: Mapping of Reviews for using the Metaverse. *IEEE Transactions on Learning Technologies*, *1*(January), 1-23. https://doi.org/10.1109/TLT.2023.3243946.

Bell, I., Laurie, N., Calle, O., Carmen, M., & Valdez, A. (2024). Education for disaster resilience: Lessons from El Niño. *Geoforum*, *148*(November 2023), 103919.1-11. https://doi.org/10.1016/j.geoforum.2023.103919.

Bibri, S. E., & Jagatheesaperumal, S. K. (2023). Harnessing the Potential of the Metaverse and Artificial Intelligence for the Internet of City Things: Cost-Effective XReality and Synergistic AIoT Technologies. *Smart Cities*, *6*(5), 2397–2429. https://doi.org/10.3390/smartcities6050109.

Braun-Lewensohn, O., Abu-Kaf, S., & Al-Said, K. (2019). Women in refugee camps: Which coping resources help them to adapt? *International Journal of Environmental Research and Public Health*, *16*(20), 1-11. https://doi.org/10.3390/ijerph16203990.

Bruggeman, B., Garone, A., Struyven, K., Pynoo, B., & Tondeur, J. (2022). Exploring university teachers' online education during COVID-19: Tensions between enthusiasm and stress. *Computers and Education Open*, *3*(June), 100095. 1-13. https://doi.org/10.1016/j.caeo.2022.100095.

Campos, C. I. de, Pitombo, C. S., Delhomme, P., & Quintanilha, J. A. (2020). Comparative analysis of data reduction techniques for questionnaire validation using self-reported driver behaviors. *Journal of Safety Research*, *73*(2), 133–142. https://doi.org/10.1016/j.jsr.2020.02.004.

Charondo, L. B., Brian, R., Syed, S., Chern, H., Lager, J., Alseidi, A., O'Sullivan, P., & Bayne, D. (2023). Confronting new challenges: Faculty perceptions of gaps in current laparoscopic curricula in a changing training landscape. *Surgery Open Science*, *16*(September), 1–7. https://doi.org/10.1016/j.sopen.2023.09.006.

Chen, X., Zou, D., Cheng, G., & Xie, H. (2020). Detecting latent topics and trends in educational technologies over four decades using structural topic modeling: A retrospective of all volumes of Computers & Education. *Computers and Education*, *151*(September 2019), 103855.1-21. https://doi.org/10.1016/j.compedu.2020.103855.

De Felice, F., Petrillo, A., Iovine, G., Salzano, C., & Baffo, I. (2023). How Does the Metaverse Shape Education? A Systematic Literature Review. *Applied Sciences (Switzerland)*, *13*(9), 1-24. https://doi.org/10.3390/app13095682.

Fàbregues, S., Sáinz, M., Romano, M. J., Escalante-Barrios, E. L., Younas, A., & López-Pérez, B. S. (2023). Use of mixed methods research in intervention studies to increase young people's interest in STEM: A systematic methodological review. *Frontiers in Psychology*, *13*(January), 1–14. https://doi.org/10.3389/fpsyg.2022.956300.

Fedorov, A., & Mikhaleva, G. (2020). Current trends in media and information literacy in research and scientific publications of the early 21st century. *International Journal of Media and Information Literacy*, *5*(2), 153–163. https://doi.org/10.13187/IJMIL.2020.2.153.

Feng, D. C., Liu, Z. T., Wang, X. D., Chen, Y., Chang, J. Q., Wei, D. F., & Jiang, Z. M. (2020). Machine learning-based compressive strength prediction for concrete: An adaptive boosting approach. *Construction and Building Materials*, *230*(January), 1-20. https://doi.org/10.1016/j.conbuildmat.2019.117000.

Fütterer, T., Scheiter, K., Cheng, X., & Stürmer, K. (2022). Quality beats frequency? Investigating students' effort in learning when introducing technology in classrooms. *Contemporary Educational Psychology*, *69*(January), 102042.1-20. https://doi.org/10.1016/j.cedpsych.2022.102042.

Golf-Papez, M., Heller, J., Hilken, T., Chylinski, M., de Ruyter, K., Keeling, D. I., & Mahr, D. (2022). Embracing falsity through the metaverse: The case of synthetic customer experiences. *Business Horizons*, *65*(6), 739–749. https://doi.org/10.1016/j.bushor.2022.07.007.

Goode, K. L., Dunphy, B. J., & Parsons, D. M. (2020). Environmental metabolomics as an ecological indicator: Metabolite profiles in juvenile fish discriminate sites with different nursery habitat qualities. *Ecological Indicators*, *115*(November 2019), 1-13. https://doi.org/10.1016/j.ecolind.2020.106361.

Guggemos, J., & Seufert, S. (2021). Computers in Human Behavior Teaching with and teaching about technology – Evidence for professional development of in-service teachers. *Computers in Human Behavior*, *115*(November 2020), 106613.1-11. https://doi.org/10.1016/j.chb.2020.106613.

Gupta, S., Montenovo, L., Nguyen, T., Lozano-Rojas, F., Schmutte, I., Simon, K., Weinberg, B. A., & Wing, C. (2023). Effects of social distancing policy on labor market outcomes. *Contemporary Economic Policy*, *41*(1), 166–193. https://doi.org/10.1111/coep.12582.

Haltas, I., Yildirim, E., Oztas, F., & Demir, I. (2021). A comprehensive flood event specification and inventory: 1930–2020 Turkey case study. *International Journal of Disaster Risk Reduction*, *56*(1), 1–13. https://doi.org/10.1016/j.ijdrr.2021.102086.

Hassan, C., East, J., Radaelli, F., Spada, C., Benamouzig, R., Bisschops, R., Bretthauer, M., Dekker, E., Dinis-Ribeiro, M., Ferlitsch, M., Fuccio, L., Awadie, H., Gralnek, I., Jover, R., Kaminski, M. F., Pellisé, M., Triantafyllou, K., Vanella, G., Mangas-Sanjuan, C., … Dumonceau, J. M. (2019). Bowel preparation for colonoscopy: European society of gastrointestinal endoscopy (esge) guideline-update 2019. *Endoscopy*, *51*(8), 775–794. https://doi.org/10.1055/a-0959-0505.

Herrera-Franco, G., Montalván-Burbano, N., Carrión-Mero, P., Apolo-Masache, B., & Jaya-Montalvo, M. (2020). Research trends in geotourism: A bibliometric analysis using the scopus database. *Geosciences (Switzerland)*, *10*(10), 1–29. https://doi.org/10.3390/geosciences10100379.

Huang, B., Siu-Yung Jong, M., Tu, Y. F., Hwang, G. J., Chai, C. S., & Yi-Chao Jiang, M. (2022). Trends and exemplary practices of STEM teacher professional development programs in K-12 contexts: A systematic review of empirical studies. *Computers and Education*, *189*(June), 104577.1-24. https://doi.org/10.1016/j.compedu.2022.104577.

Kasneci, E., Sessler, K., Küchemann, S., Bannert, M., Dementieva, D., Fischer, F., Gasser, U., Groh, G., Günnemann, S., Hüllermeier, E., Krusche, S., Kutyniok, G., Michaeli, T., Nerdel, C., Pfeffer, J., Poquet, O., Sailer, M., Schmidt, A., Seidel, T., … Kasneci, G. (2023). ChatGPT for good? On opportunities and challenges of large language models for education. *Learning and Individual Differences*, *103*, 102274. https://doi.org/10.1016/j.lindif.2023.102274.

Kuhail, M. A., Elsayary, A., Farooq, S., & Alghamdi, A. (2022). Exploring Immersive Learning Experiences: A Survey. *Informatics*, *9*(4), 1-22. https://doi.org/10.3390/informatics9040075.

Lemay, D. J., Baek, C., & Doleck, T. (2021). Comparison of learning analytics and educational data mining: A topic modeling approach. *Computers and Education: Artificial Intelligence*, *2*(December 2020), 100016.1-14. https://doi.org/10.1016/j.caeai.2021.100016.

Lumbantoruan, J. H., & Ditasona, C. (2024). Development of a mathematics module on circle material based on the small group discussion model. *Journal of Education and Learning (EduLearn)*, *18*(1), 18–25. https://doi.org/10.11591/edulearn.v18i1.20920.

Lumbantoruan, J. H. H. (2022). Impact of Unprepared Competence and Difficulty in Competence of Mathematics Teachers During Online Learning. *JTAM (Jurnal Teori dan Aplikasi Matematika)*, *6*(4 (2022): October), 876–892. https://doi.org/10.31764/jtam.v6i4.9164.

Lumbantoruan, J. H., & Manalu, R. U. (2024). Effectiveness of learning mathematics derivative materials using modules equipped with cooperative models in high schools. *International Journal of Evaluation and Research in Education* , *13*(1), 523–533. https://doi.org/10.11591/ijere.v13i1.25354.

Mishra, L., Gupta, T., & Shree, A. (2020). Online teaching-learning in higher education during lockdown period of COVID-19 pandemic. *International Journal of Educational Research Open*, *1*, 100012. https://doi.org/10.1016/j.ijedro.2020.100012.

Mousa, S. K., & Othman, M. (2020). The impact of green human resource management practices on sustainable performance in healthcare organisations: A conceptual framework. *Journal of Cleaner Production*, *243*(1), 1–63. https://doi.org/10.1016/j.jclepro.2019.118595.

Mustapha, I., Van, N. T., Shahverdi, M., Qureshi, M. I., & Khan, N. (2021). Effectiveness of Digital Technology in Education During COVID-19 Pandemic. A Bibliometric Analysis. *International Journal of Interactive Mobile Technologies*, *15*(8), 136–154. https://doi.org/10.3991/ijim.v15i08.20415.

Onu, P., Pradhan, A., & Mbohwa, C. (2023). Potential to use metaverse for future teaching and learning. In *Education and Information Technologies* (Number August). https://doi.org/10.1007/s10639-023-12167-9.

ÖZDEMİR, D., & ÖZÇAKIR, B. (2019). Kesirlerin Öğretiminde Artırılmış Gerçeklik Etkinliklerinin 5.sınıf Öğrencilerinin Matematik Başarılarına ve Tutumlarına Etkisinin İncelenmesi. *Adıyaman Üniversitesi Eğitim Bilimleri Dergisi*, *9*(1), 21–41. https://doi.org/10.17984/adyuebd.495731.

Özdemir, Ş. (2022). Remote schooling during a pandemic: Visibly Muslim mothering and the entanglement of personal and political. *Gender, Work and Organization*, *29*(4), 1375–1385. https://doi.org/10.1111/gwao.12819.

Pahmi, S., Hendriyanto, A., Sahara, S., Muhaimin, L. H., Kuncoro, K. S., & Usodo, B. (2023). Assessing the Influence of Augmented Reality in Mathematics Education: A Systematic Literature Review. *International Journal of Learning, Teaching and Educational Research*, *22*(5), 1–25. https://doi.org/10.26803/ijlter.22.5.1.

Pellegrino, A., Wang, R., & Stasi, A. (2023). Exploring the intersection of sustainable consumption and the Metaverse: A review of current literature and future research directions. *Heliyon*, *9*(9), e19190.1-17. https://doi.org/10.1016/j.heliyon.2023.e19190.

Pizzolante, M., Borghesi, F., Sarcinella, E., Bartolotta, S., Salvi, C., Cipresso, P., Gaggioli, A., & Chirico, A. (2023). Awe in the metaverse: Designing and validating a novel online virtual-reality awe-inspiring training. *Computers in Human Behavior*, *148*(February), 107876.1-14. https://doi.org/10.1016/j.chb.2023.107876.

Polas, M. R. H., Afshar Jahanshahi, A., Kabir, A. I., Sohel-Uz-Zaman, A. S. M., Osman, A. R., & Karim, R. (2022). Artificial Intelligence, Blockchain Technology, and Risk-Taking Behavior in the 4.0IR Metaverse Era: Evidence from Bangladesh-Based SMEs. *Journal of Open Innovation: Technology, Market, and*

Complexity, *8*(3), 1-24. https://doi.org/10.3390/joitmc8030168.

Reer, F., Wehden, L. O., Janzik, R., Tang, W. Y., & Quandt, T. (2022). Virtual reality technology and game enjoyment: The contributions of natural mapping and need satisfaction. *Computers in Human Behavior*, *132*(1), 107242.10. https://doi.org/10.1016/j.chb.2022.107242.

Sakaria, D., Maat, S. M., & Mohd Matore, M. E. E. (2023). Examining the Optimal Choice of SEM Statistical Software Packages for Sustainable Mathematics Education: A Systematic Review. *Sustainability (Switzerland)*, *15*(4), 1-23. https://doi.org/10.3390/su15043209.

Scorolli, C., Naddei Grasso, E., Stacchio, L., Armandi, V., Matteucci, G., & Marfia, G. (2023). Would you rather come to a tango concert in theater or in VR? Aesthetic emotions & social presence in musical experiences, either live, 2D or 3D. *Computers in Human Behavior*, *149*(August), 107910.1-20. https://doi.org/10.1016/j.chb.2023.107910.

Scurati, G. W., Bertoni, M., Graziosi, S., & Ferrise, F. (2021). Exploring the use of virtual reality to support environmentally sustainable behavior: A framework to design experiences. *Sustainability (Switzerland)*, *13*(2), 1–20. https://doi.org/10.3390/su13020943.

Selvaraj, A., Radhin, V., KA, N., Benson, N., & Mathew, A. J. (2021). Effect of pandemic based online education on teaching and learning system. *International Journal of Educational Development*, *85*(May), 102444. https://doi.org/10.1016/j.ijedudev.2021.102444.

Seufert, S., Guggemos, J., & Sailer, M. (2021). Technology-related knowledge, skills, and attitudes of pre- and in-service teachers: The current situation and emerging trends. *Computers in Human Behavior*, *115*(May 2020), 106552.1-7. https://doi.org/10.1016/j.chb.2020.106552.

Srivastava, A., Gupta, M. S., & Kaur, G. (2020). Energy efficient transmission trends towards future green cognitive radio networks (5G): Progress, taxonomy and open challenges. *Journal of Network and Computer Applications*, *168*(2), 1-39. https://doi.org/10.1016/j.jnca.2020.102760.

Støle, H., Mangen, A., & Schwippert, K. (2020). Assessing children's reading comprehension on paper and screen: A mode-effect study. *Computers and Education*, *151*(February), 1-13. https://doi.org/10.1016/j.compedu.2020.103861.

Tirachini, A., Chaniotakis, E., Abouelela, M., & Antoniou, C. (2020). The sustainability of shared mobility: Can a platform for shared rides reduce motorized traffic in cities? *Transportation Research Part C: Emerging Technologies*, *117*(1), 1-26. https://doi.org/10.1016/j.trc.2020.102707.

Tlili, A., Huang, R., Shehata, B., Liu, D., Zhao, J., Metwally, A. H. S., Wang, H., Denden, M., Bozkurt, A., Lee, L. H., Beyoglu, D., Altinay, F., Sharma, R. C., Altinay, Z., Li, Z., Liu, J., Ahmad, F., Hu, Y., Salha, S., … Burgos, D. (2022). Is Metaverse in education a blessing or a curse: a combined content and bibliometric analysis. *Smart Learning Environments*, *9*(1), 1-31. https://doi.org/10.1186/s40561-022-00205-x.

Yu, C. (2019). *Yu CH , Tsai CC , Wang Y , Lai KK , Tajvidi M . Towards Building a Value Co-Creation Circle in Social Commerce . Computers in Human Behavior 2018 DOI : https://doi.org/10.1016/j.chb.2018.04.021 Towards Building a Value Co-Creation Circle in Social Commerc*. *2*(April), 1–26. https://doi.org/https://doi.org/10.1016/j.chb.2018.04.021.