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THE ESSENTIAL COMPONENTS OF METAVERSE-BASED MIXED REALITY FOR MACHINERY VOCATIONAL SCHOOLS

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ABSTRACT
Every nation is interested in the best practices of those with high enrolment in vocational schools and low young unemployment rates. We'd like to build robust systems that can deal with issues like the quick pace of technology development and the mismatch between supply and demand in the job market. Since Mark Zuckerberg rebranded the company as Meta in 2021, the Metaverse has seen a rise in popularity. The same can be said about mixed reality, which is currently in the spotlight following the release of Microsoft's first HoloLens. The authors propose a mixed reality as a means of resolving the problem of inadequately meeting the demand for skilled workers. The purpose of this study is to help machinery vocational schools decide whether or not to adopt a mixed reality as a teaching and learning tool by identifying the most important components of a metaverse-based mixed reality for such institutions and which metaverse type mixed reality belongs to. This study uses a methodology that is developed by the authors to accommodate the true or natural flow of this research. The results of this study are to provide the essential elements of mixed reality systems as the mixed reality systems are not part of any metaverse type. The implication of this study is since mixed reality is the combination of several metaverse types, the essential elements of mixed reality systems are taken from the components of the other metaverse types. The results of this study are to be a guide of what needs to be prepared before implementing a mixed reality system.
Keywords: *Machinery Vocational School, Mixed Reality, Metaverse Type, Metaverse Components*

1. Introduction

Industry 1.0 gave way to Industry 4.0, and now we're in an era of Industry 5.0 that leads to the formation of Society 5.0, which necessitates a higher level of human competency than ever before because employers expect graduates to be ready-to-work products rather than having to train them from scratch, the industrial revolutions can be seen in Fig 1. Vocational programs equip students with the necessary skills and knowledge for immediate employment by offering a blend of experiential learning, practical skill-building, and certifications that are relevant to the industry. Vocational education guarantees that graduates possess the requisite technical abilities, practical knowledge, and professional skills desired by employers by closely connecting the curriculum with current industry needs and trends. Vocational education is a crucial gateway to success in the current labor market since it not only improves graduates' chances of finding employment but also prepares them to excel in their chosen careers right from the start, boosting their confidence and readiness(Pembinaan Sekolah Menengah Kejuruan Direktorat Jenderal Pendidikan Dasar Dan Menengah Kementerian Pendidikan Dan Kebudayaan & Bursa Pasar Tenaga Kerja, 2019).

Industry 5.0 and Society 5.0 represent significant changes in both industrial methods and social frameworks. Industry 5.0 focuses on the collaboration between humans and machines, utilizing sophisticated technology such as artificial intelligence and robots to increase production while maintaining the distinct abilities of human workers. This strategy promotes comprehensive and enduring industrial growth, guaranteeing the generation of employment opportunities and fostering innovation. Society 5.0 envisions a society that prioritizes human needs and utilizes technology to bring together the digital and physical worlds to tackle intricate problems and enhance the overall quality of life. Society 5.0 utilizes technology such as IoT and big data to enhance connectedness, efficiency, and equity. It provides solutions to urgent problems like as urbanization, aging populations, and environmental degradation. These paradigms are essential in negotiating the intricacies of technological innovation, developing resilience, and fostering inclusivity in today's socio-economic landscape (Fogarty, 2023).

Vocational schools aim to help students develop marketable skills and position themselves favorably in the increasingly competitive global marketplace for businesses and industries (Maruanaya & Hariyanto, 2021; Suharno et al., 2020). There is still a skills gap between newly graduated workers and the industry, but it may be narrowed by enhancing or altering vocational education. The quality of the equipment used for studying and conducting practical exams may be the cause of the current discrepancy. One of the primary problems in the machinery vocational school is the equipment or the machines for the students. Examples include machines that are not enough for the number of students enrolled, machines that are broken, and inadequate electricity to run all the machines (Purwanto & Sukardi, 2015). Based on that condition, the author can conclude that not all students have the same opportunity to have hands-on experience due to the ratio of the number of machines are not proper. Even if they have the opportunity, the machine might be too old and it makes the technology of the particular machine not relevant to the current technology.

Unfortunately, the current state of vocational education does not meet the industry's basic requirements, making it nearly hard for graduates to find work in their field when they complete their studies as a result, there is a need to revise the approach used to teaching and learning at vocational institutions (Durmus & Dağlı, 2017).

One of our previous research has demonstrated that the usage of MR systems can enhance student engagement due to their advanced interactive features (Christopoulos et al., 2018). Student interest is significantly influenced by learning engagement. In addition to learning engagement, several other advantages significantly contribute to student interest, including authenticity, social presence, spatial presence, and emotiveness (Tenberg, 2015). The systematic literature review reveals numerous advantages associated with the utilization of MR systems. The top five benefits include: (1) enhanced learning engagement, (2) heightened interactivity, (3) increased motivation, (4) improved teaching and learning effectiveness, and (5a) superior learning outcomes, along with (5b) experiential learning (S. P. Suryodiningrat et al., 2021).

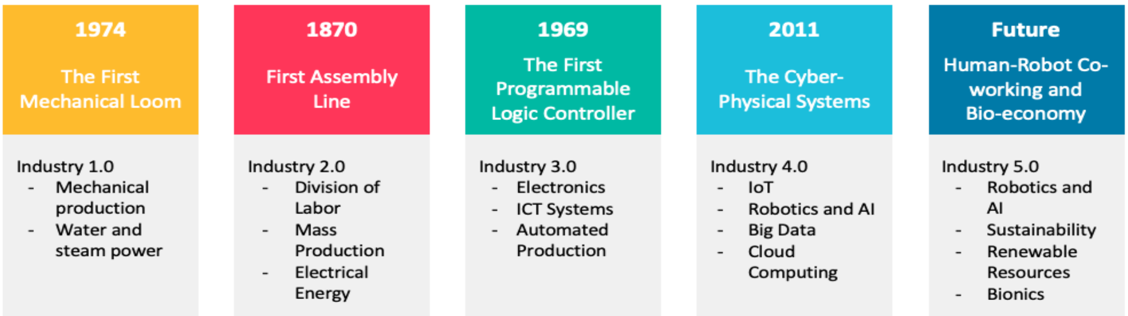

Fig. 1 Industrial Revolutions Timeline

Most corporations throughout the world, including education institutions, have already allocated marketing or innovation funds to explore the metaverse (Clement, 2022b) (Clement, 2022a), indicating that they regard it as a promising commercial potential. Any government may use the resources of the Metaverse to create more effective e-government and better serve its citizens. The term "metaverse" is an anagram of "meta-" and "universe," respectively. Since "meta" comes from the Greek for "beyond," "universe" refers to the entire planet. When you put the two together, you get metaverse, which is short for "meta-world" (Mystakidis, 2022). Snow Crash, a science fiction novel written by Niel Stephenson, is credited with coining the term "metaverse." The metaverse has great potential for nations whose economies rely primarily on the harvest (Suroso & Ramadhan, 2012). Companies in the computer and IT industries have made the most investments in the metaverse worldwide in 2022, followed by those in the education and financial sectors [5]. According to Petrosyan, the top three reasons why people find the metaverse appealing are (1) the belief that the metaverse would overcome numerous hurdles including impairments, (2) the belief that the metaverse will boost creativity and imagination, and (3) the belief that visiting the world without really going, known as MetaToursim, is something novel (Petrosyan, 2021).

Referring to Clement's survey data shows that the education industry is the second most profitable overall. Improving educational opportunities for current and future generations has long been recognized as a key to a prosperous nation and a stable social order (Clement, 2022b). The advancement of the metaverse has the potential to significantly improve the standard of education. Studies show that using technology to aid in one's education improves one's ability to retain information (P. J. H. Hu & Hui, 2012). Learning in the metaverse has several good effects on education, including providing students with a novel environment in which to interact and learn, and increasing their freedom to speak their minds and collaborate on projects (Kye et al., 2021). Since all students in the metaverse have the same access to resources, the quality of their education will be uniform across the board (Park & Kim, 2022). And the course materials can be tailored to each learner and their learning style (Jaecheon Jeon, 2021).

As seen in Table 1, there are four distinct varieties of the metaverse including technologies like Augmented Reality (AR), lifelogging, Mirror World (MW)/Digital Twin (DT), and Virtual World (VR). One source refers to the four metaverse kinds as a platform, while others refer to them as categories, classifications, characteristics, platforms, services, and a spectrum. Others may refer to the four categories of the metaverse by different names, but the author is confident that they all refer to the same entity (S. P. Suryodiningrat et al., 2022).

Table 1- Types of Metaverse

	External	Intimate
Augmentation	Augmented Reality	Lifelogging
Simulation	Mirror Worlds/Digital Twin	Virtual Worlds

Many details concerning metaverse components were uncovered by other research on the types and platforms of metaverse (S. P. Suryodiningrat et al., 2022). AR, lifelogging, VR, and mixed reality/DT are the four categories of the metaverse. Human-Computer Interaction (HCI) is the most important part of augmented reality. This entails the users' ability to make decisions, take action, and relocate. This component is crucial since it improves the overall user experience. The authors discovered just a camera as a lifelogging component. This is intriguing since lifelogging encompasses the use of any wearable gadget to track a person's activities not just for fun, but also for health purposes, such as a heart rate monitor. However, lifelogging is still misunderstood. The third category of metaverses is virtual reality, and in this category, two aspects, namely 3D representations of both the human body and the surrounding environment, and motion recognition, are making equal appearances. It's not hard to see why these two components are so crucial. The mirror world, or the digital world, has the same number of occurrences of the top three elements as the physical world: 3D models at the top, a physical system, and real-time monitoring.

Mixed reality merges the digital and physical realms to create a dynamic and interactive space where new landscapes and representations can be developed (Kim et al., 2021). Unlike VR, which isolates its users from the actual world, mixed reality allows them to interact with both the real and virtual worlds simultaneously, resulting in novel and engaging experiences that exist in neither one nor the other alone. Using mixed reality, students may soon be able to participate in engaging courses without ever leaving their homes. Based on the authors' previous research results shown in Table 2, most mixed reality (55%) were used at K-12 institutions, probably because of financial constraints and the relative ease of developing content for this audience. The second largest group was educational institutions (32%), where the wide variety of majors presents unique challenges for content creation. The lowest percentage of mixed reality was found in vocational schools (13%), perhaps because vocational schools are less likely to employ technology and are more likely to emphasize practical application (S. P. Suryodiningrat et al., 2023).

The majority of mixed reality may be found in elementary and secondary schools. Consistent with Weng et al findings (Weng et al., 2019). They said elementary and high school pupils may use mixed reality devices in classrooms. Mixed reality systems have a wide range of potential applications in K-12 education, particularly in the STEM fields. Weng et al. found that using mixed reality improved student performance in chemistry, biology, and physics. Mixed reality systems are becoming increasingly commonplace, with applications spanning the fields of information visualization, collaboration, human-machine interaction, and education and training (Quint et al., 2015). According to Juraschek et al., bringing the real and virtual worlds together through the use of a mixed-reality system in classrooms improves student achievement (Juraschek et al., 2018). However, mixed reality in higher education are decades ahead of their use in K-12. Despite the evidence presented above, it appears that mixed reality has not yet been implemented as a teaching tool in vocational institutions. The advantages of mixed reality for education are numerous; hence, vocational institutions would do well to incorporate them into their pedagogical practices. This research seeks to find the essential components of mixed reality and determine which metaverse type the mixed reality belongs to, expanding on our earlier research on the components of each metaverse type.

Table 2 - Fields of Mixed Reality Being Implemented (S. P. Suryodiningrat et al., 2023)

No.	Area/Fields	Volume	Percentage
1	K-12 schools	26	55%
2	Universities or Higher Education	15	32%
3	Vocational schools	6	13%

The majority of mixed reality may be found in elementary and secondary schools. Consistent with Weng et al findings (Weng et al., 2019). They said elementary and high school pupils may use mixed reality devices in classrooms. Mixed reality systems have a wide range of potential applications in K-12 education, particularly in the STEM fields. Weng et al. found that using mixed reality improved student performance in chemistry, biology, and physics. Mixed reality systems are becoming increasingly commonplace, with applications spanning the fields of information visualization, collaboration, human-machine interaction, and education and training (Quint et al., 2015). According to Juraschek et al., bringing the real and virtual worlds together through the use of a mixed-reality system in classrooms improves student achievement (Juraschek et al., 2018). However, mixed reality in higher education are decades ahead of their use in K-12. Despite the evidence presented above, it appears that mixed reality has not yet been implemented as a teaching tool in vocational institutions. The advantages of mixed reality for education are numerous; hence, vocational institutions would do well to incorporate them into their pedagogical practices. This research seeks to find the essential components of mixed reality and determine which metaverse type the mixed reality belongs to, expanding on our earlier research on the components of each metaverse type.

2. Previous Research

For their prior studies, the authors used the SLR method developed by Kitchenham (Kitchenham, 2007) represented in Figure 2 below. To identify elements from all four types of metaverses, researchers must answer four questions, elements of Metaverse type: Augmented Reality (AR), Lifelogging, Virtual Worlds (VR), and Mirror World or Digital Twin (P. S. Suryodiningrat & Ramadhan, 2023).

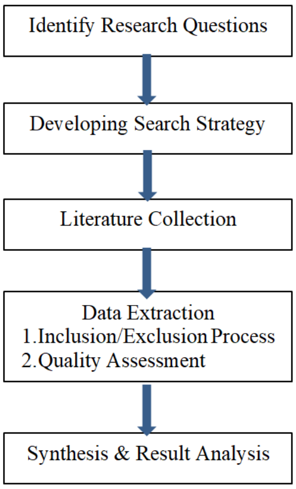

Fig. 2. The Steps of The Study

The next stage is to establish the SLR's search methodology. The first step was to settle on a database of choice. The authors have opted to utilize several different databases, some of which include the ACM Digital Library, IEEE Xplore, and Springer. The author then searched from January 2019 through December 2022 using the keywords "elements of" AND "lifelogging or augmented reality or virtual reality or digital twin or mirror world" in the selected databases. At this point, the authors started searching for the selected keywords in the selected databases to collect the relevant literature.

Using inclusion and exclusion criteria (Table 3), the authors narrowed down the 41 papers they found to only those that were a good fit for their study in terms of answering their research objectives and providing reliable data. The authors narrowed their selection down to 31 publications by excluding 8. Elsevier has two books, IEEE has three, MDPI has one, Springer has one, and Taylor & Francis has one. All eight posts were taken down because they fell short of expectations in the lifelogging, AR/VR, and DW/MW (digital twin/mirror world) categories.

Table 3 - Inclusion and Exclusion Criteria

Inclusion	Exclusion
1. Publications from 2019 to Q1 of 2023	1. Papers that are non-accessible.
2. Providing the appropriate results the elements of lifelogging, augmented reality, virtual reality, and digital twin or mirror world	
3. The language of the papers is English	

The chosen publications mostly feature contributions from IEEE, Springer, and MDPI. Journal articles are the most common, followed by those presented at conferences and chapters in books. The selected papers' quality is evaluated by the authors, who read each one carefully to see if it is well-written and has contributions that help answer our research objectives. All authors believe that after a thorough quality evaluation procedure, those 33 papers are of sufficient quality to be incorporated into the synthesis. The quality assessment checklist is outlined below:

1. Are the research questions/objectives well-articulated?
2. Does the essay effectively fulfill its intended questions and purposes through its design?
3. Are the data collection procedures sufficiently described?
4. Do the findings align with the research aims/objective?
5. Are there any explicit declarations of the discoveries?

The quality evaluation checklist assigns a numerical value to each question using a three-point scale. A response of "Yes" is given a score of 1 point, "Partially" is assigned 0.5 points, and "No" receives 0 points. Every author participates in the process of evaluating the quality. Every author evaluates all articles using the 8 question items from the checklist. The discrepancies in scores among the authors were resolved through subsequent deliberation until a unanimous agreement was reached. Next, the cumulative score for each article is computed, along with the corresponding percentage relative to the ideal value (a score of 5).

Table 4 contains some of the descriptive material from the article that has been incorporated into the American Psychological Association (APA) reference style and linked to the relevant reference, where J is for Journal, BC is for Book Chapter, and P is for Proceeding. Table 5 displays the outcomes of the synthesis.

Table 4 - The Descriptive Information

No	Author	Metaverse Type	Publication	Database
1	(Cuevas-Lara *et al*., 2020)	VR	J	MDPI
2	(Vorländer, 2020)	VR	BC	Springer
3	(Ladj *et al*., 2020)	MW	J	Elsevier
4	(Ralston *et al*., 2020)	MW	J	Taylor & Francis
5	(Šimoník & Krumnikl, 2022)	AR and VR	J	Springer
6	(Ksibi *et al*., 2021a)	Lifelogging	J	IEEE
7	(Cuevas-Lara *et a*l., 2020; Struková et al., 2022)	MW	P	IOP
8	(D. Lu *et al*., 2021)	VR	J	Springer
9	(Y. Lu *et al*., n.d.)	AR	P	IEEE
10	(Williams *et al*., 2020)	VR	P	IEEE
11	(Pietroni, 2019)	VR	J	MDPI
12	(Salim *et al*., 2022)	VR	P	IEEE
13	(Zhang *et al*., 2019)	VR	P	ACM
14	(Liu *et al*., 2022)	MW	J	MDPI
15	(Nasirahmadi & Hensel, 2022)	MW	J	MDPI
16	(Miller *et al*., 2021)	VR	P	IEEE
17	(Romli *et al*., 2020)	AR	P	IOP
18	(Goos *et al*., 2020)	VR	BC	Springer
19	(Z. Li *et al*., 2021)	VR	P	IEEE
20	(King *et al*., 2020)	AR	P	IEEE
21	(Gupta Aboul Ella Hassanien Ashish Khanna Editors, 2020)	VR	BC	Springer
22	(İyigün *et al*., 2022)	VR	BC	Springer
23	(Promod *et al*., 2019)	VR	P	IEEE
24	(Ding *et al*., 2022)	AR	P	IEEE
25	(Hachaj & Piekarczyk, 2019)	VR	J	MDPI
26	(Bonmarin *et al*., 2022)	AR	J	MDPI
27	(Lee *et al*., 2020)	VR	J	MDPI
28	(Dargan *et al*., 2022)	AR	J	Springer
29	(Xia *et al*., 2020)	AR	P	IEEE
30	(J. Li *et al*., 2021)	VR	P	IEEE
31	(Hughes *et al*., 2022)	MW	J	Elsevier
32	(Ogasawara & Bandai, 2020)	VR	P	IEEE
33	(Slavkovic *et al*., 2020)	MW	J	Springer

Table 5 - Complete Components of Each Metaverse Type

Augmentation	• HCI (Choice, Action, and Movement) • Images • Location • 3D model • Camera • Video • Sound • NED • Shadow
Lifelogging	• Camera
Mirror Worlds	• 3D models (human and environment) • Movement recognition • HMD (Head-mounted display) • Omnidirectional video • Augmented reality • Visuo-haptic feedback • Multisensory integration • Virtual stereo • Imagination • Marker-less object recognition, device calibration
Virtual Worlds	• 3D models • Physical system • Real-time monitoring • Platform (i.e., geospatial) • Classification models • Vibrational analysis

Virtual Reality (VR), Augmented Reality (AR), Digital Twins, and Mirror Worlds provide unique advantages for vocational education. Virtual reality (VR) allows students to fully engage in lifelike simulations of professional work settings, facilitating experiential learning and proficiency growth in areas such as healthcare, manufacturing, and construction. Augmented reality (AR) superimposes digital information onto real-world environments, enabling interactive learning experiences that allow students to view and engage with equipment, machines, or processes. This enhances their understanding and memory retention. Digital Twins generate virtual duplicates of tangible systems, enabling students to see and control variables in real time, promoting enhanced comprehension of intricate systems and problem-solving abilities. Mirror Worlds offers virtual renditions of physical spaces, allowing students to remotely investigate and analyze environments, thereby facilitating distant collaboration and fieldwork in vocational domains such as urban planning or architecture. Each of these technologies improves vocational education by offering immersive, interactive, and flexible learning experiences that connect classroom instruction with real-world practice, effectively equipping students for successful careers in their chosen fields.

The metaverse has the potential to revolutionize vocational education by providing customized and engaging learning experiences that are specifically designed for different industries and occupations. Vocational education can utilize technologies such as virtual reality (VR), augmented reality (AR), digital twins, and mirror worlds to create lifelike business situations. This allows students to receive practical training and gain hands-on skills that will benefit them . VR simulations may accurately reproduce perilous situations or intricate machinery, enabling students to rehearse safety practices and equipment operation within a secure and regul(Khaled et al., 2014)ated environment. Augmented reality (AR) enhances the visualization of technical concepts or procedures by overlaying digital information onto physical objects. On the other hand, digital twins provide virtual reproductions of real-world systems for testing and analysis. Mirror worlds allow for the remote exploration of employment sites or collaborative problem-solving activities, allowing experiential learning opportunities without being limited by geographical constraints. Education in the metaverse promotes vocational training by effectively connecting theoretical knowledge with practical application. It equips students with immersive, flexible, and engaging educational experiences that prepare them for the challenges and expectations of their future employment.

This research has the potential to make significant scholarly contributions in multiple disciplines. It involves the development of innovative technology. These advancements enhance the field of computer science and technology, creating opportunities for novel applications and interactions in virtual environments. Studying the connection between individuals and the metaverse and virtual worlds can provide valuable information about human-computer interaction patterns, user behavior, and usability challenges. This study enhances user experiences and improves interface design in immersive environments. Interdisciplinary collaboration is promoted, fostering the exchange of ideas and methodologies. This interdisciplinary approach enhances understanding and promotes the creation of innovative solutions. Metaverse research has extensive implications in academics, leading to advancements in technology, social comprehension, education, economics, and various other industries. The investigation of virtual realms and immersive experiences in the digital age presents novel domains for scholarly examination and academic investigation. The pragmatic implications of this research have the potential to impact a broad spectrum of industries and aspects of everyday existence. The objective is to deliver captivating and engaging encounters for consumers. The practical contribution is to offer novel and stimulating approaches for individuals to engage with digital resources, products, services, and one another. Metaverse applications offer substantial opportunities for training and skill enhancement. Practical applications involve the utilization of virtual simulations for vocational training in several sectors such as healthcare, aviation, and engineering, among others. Metaverse technology enables remote collaboration and communication. The practical advantage is that virtual meetings, conferences, workshops, and team projects can be conducted without the need for physical presence. Metaverse research facilitates the development of personalized learning experiences that cater to the specific needs and interests of individuals. It offers tangible benefits for students seeking personalized educational resources and pathways. Metaverse-type research has a wide range of practical contributions that span across various fields, impacting industries, society, and human experiences. With the progression of technology, the metaverse is anticipated to possess a greater number of practical and transformative applications.

3. Methodology

The authors covered the methodology, as seen in Figure 3 below, which served as the foundation of this research study in this section, presenting a clear and methodical explanation of the techniques used to address the research questions or objectives. As we embark on this methodological adventure, our goal is to assure transparency, dependability, and replicability, laying the groundwork for the study's conclusions to be trusted and expanded upon.

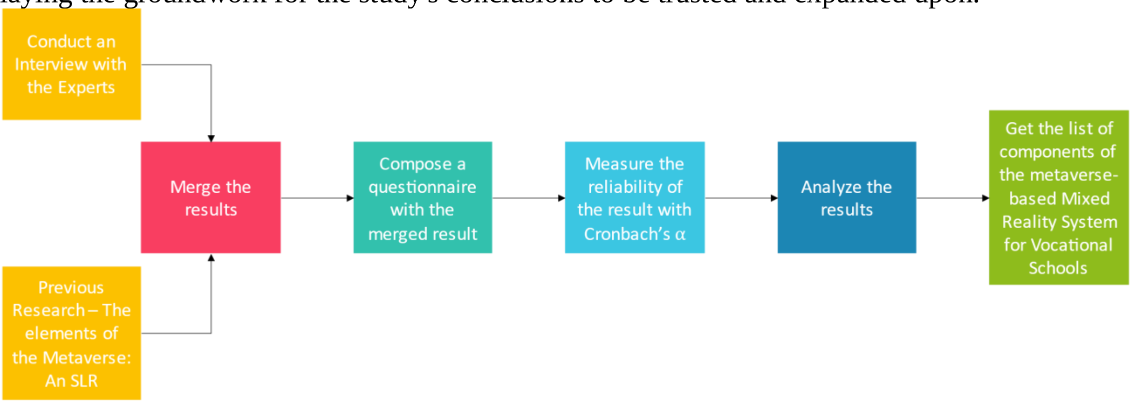

Fig. 3. Research Methodology

Participants and Context of the Study

This study included eight respondents (6 males and 2 females), 62,5% from academics and 37,5%. We invited them to be our respondents because their research and work are related to extended reality technology and the metaverse. The objective of this study refers to the rapid growth of mixed reality and metaverse, laying out the components of mixed reality, and identifying which metaverse type that mixed reality falls into. Table 6 overviews all eight respondents.

Table 6 - Respons Overview

Respondent #	Academia or Field Expert	Qualifications	Research or Work Area
Respondent 1	Academia	Professor	eXtended Reality and Education Technology
Respondent 2	Academia	Professor	HCI and Education Technology
Respondent 3	Academia	Assistant Professor	HCI and eXtended Reality
Respondent 4	Academia	Assistant Professor	Software Engineering and HCI
Respondent 5	Academia	Assistant Professor	ICT in Education
Respondent 6	Field Expert	Master's degree	eXtended Reality Lead Technology
Respondent 7	Field Expert	Master's degree	Mixed Reality, Metaverse, and Microsoft Hololens Expert
Respondent 8	Field Expert	Master's degree	Lead Programmer in eXtended Reality Projects

Data Collection Procedures

The authors did an SLR under the title "The Elements of Metaverse: A Systematic Literature Review" as mentioned in the previous research. The authors must answer 4 questions to detect elements from all four types of metaverses: Augmented Reality (AR), Lifelogging, Virtual Worlds (VR), and Mirror World or Digital Twin.

Eight respondents from the metaverse and mixed reality domains, as well as academia, online interviews were used due to time effectiveness all the respondents were interviewed by the authors and the primary goal of the interview was to learn more about their perspectives on the different types of metaverses and the components of the mixed reality for vocational schools that are based on a metaverse. After conducting interviews, the authors combine the findings with earlier research to create a questionnaire based on which they may determine which elements are crucial. In their questionnaire, the authors used a Likert scale, where 1 meant they strongly disagreed and 5 meant they strongly agreed. The same eight respondents who we spoke with were given questionnaires by the authors.

Data Analysis

After all eight respondents filled out the questionnaires, the authors then assessed the questionnaires' reliability. The concept of reliability is that the questionnaire's results stayed the same when they were repeated at a different time or occasion. Three factors, namely stability, equivalence, and consistency, might reflect dependability. The authors picked internal consistency, due to being a more particular name for consistency. Numerous studies have employed Cronbach's alpha, one of the internal consistency calculations, extensively. The reliability of the questionnaires is evaluated by the authors of this study using Cronbach's alpha. Cronbach's alpha has a value that lies between 0 and 1. In general, a survey's reliability increases with Cronbach's Alpha value. Then, after analysis of each one, a list of the fundamental elements of metaverse-based Mixed Reality systems for machinery vocational schools is produced. Figure 3 is the complete step of the authors' research methodology.

4. Results

In this result section, the authors will lay out the results of this research after following the stated methodology to answer four key questions during interviews, including: (1) Which type of Metaverse do you think Mixed Reality belongs to? (2) Which type of metaverse is suitable for machinery vocational schools to make the teaching and learning process better?, (3) What are the basic components (hardware, software, or support) that must exist for Metaverse-based Mixed Reality for Machinery Vocational Schools? Other questions emerge on their own since the conversation is so lively.

To begin, we need opinions on which Metaverse-type Mixed Reality best fits under, as our first research question. The respondents' responses to this question are particularly intriguing because 14% of them place mixed reality in the category of mirror worlds or digital twin metaverses. Respondents are split nearly evenly on whether mixed reality falls under the category of augmented reality metaverses (43%) or whether it represents an entirely new category of metaverses (43%). There has to be a new category of metaverse called Mixed Reality because it doesn't fit into any of the other ones.

The answer to the second question is the same as the first: "Which type of metaverse is suitable for Metaverse-based machinery vocational schools to make the teaching and learning process better?" 14% percent think that the mirror world is the best metaverse setting for a school specializing in machinery. Among them, 43% think that AR is the best option. Additionally, 43% of respondents think that mixed reality metaverses will be the best fit for machinery vocation schools in the future. You may view the answers to questions 1 and 2 combined in Table 7.

Results and Discussion is a section that contains all scientific findings obtained as research data. This section is expected to provide a scientific explanation that can logically explain the reason for obtaining those results that are clearly described, complete, detailed, integrated, systematic, and continuous.

Table 7 - Results of Questions 1 and 2

Metaverse Type for mixed reality	Suitable Metaverse for Machinery Vocational School	Percent
Mirror World	Mirror World	14%
Augmented Reality	Augmented Reality	43%
Mixed Reality	Mixed Reality	43%

There is a great deal of variation in the answers to the basic components (hardware, software, or support) that must exist for Metaverse-based Mixed Reality for Machinery Vocational School, as our final research question. We'll begin with the physical parts. Everyone responds The HoloLens from Microsoft is a must-have for any machinery vocational school. The answer includes not only a Microsoft HoloLens, but also a smartphone, tablet, and server. If we're going to keep talking about software parts, it's important to note that all respondents believe that content is the most crucial part. Microsoft Guide, Microsoft Mesh, other platforms to be integrated, a 3D model, interactivity, artificial intelligence, and machine learning also make appearances during the interview as additional software components. All of them make an appearance during one of the interviews. In addition to hardware and software, we also need supplementary components. Interviewees are unanimous that having access to the internet is crucial, second only to having a physical object and a server on which to store information. The survey's key findings are tabulated in Table 8.

Table 8 - Summary of Interview Results

Hardware	Volume	Software	Volume	Supporting	Volume
Microsoft HoloLens	7	Content	7	Internet	7
Smartphone	1	Microsoft Dynamic	1	Real object	1
Tablet	1	Microsoft Mesh	1	Server	1
Server	1	Other Platforms	1		
		3D Model	1		
		Interactivity	1		

	Artificial Intelligent	1
	Machine Learning	1

After finalizing the interview session results, the authors integrate the list from the prior research with the interview session results. The authors then develop a Likert-Scale questionnaire for each topic to determine the amount of agreement or disagreement with the essential components of metaverse-based mixed reality for machinery vocational schools, and the results can be seen in Table 9. When the questionnaire has been sent to the same eight respondents to complete it to finalize the list of necessary components. The surveys were completed, and Cronbach's alpha value is 0.935. This indicates that the questionnaire is reliable. However, based on the interview results we deleted camera and visuo-haptic feedback because it is unnecessary for the mixed reality system.

Table 9 - The Essential Components of Metaverse-based Mixed Reality System for Machinery Vocational Schools

Category	Components	Mean
Hardware	Near Eye Display (NED) or Head-Mounted Display (HMD)	4,88
	Server	4,75
	Physical System for digital twin	4,63
Software	Device Calibration	4,88
	Real-time Monitoring for digital twin	4,38
	Machine learning	4,38
	Artificial Intelligence	4,50
Content	Human-Computer Interaction (HCI)	4,88
	Sound and spatial sound	4,88
	Markerless Object Recognition	4,88
	3D model	4,75
	Location technology	4,63
	Multisensory Integration	4,63
	Video	4,50
	Omnidirectional Video	4,50
	Shadow	4,25
	Images	4,13
Connectivity	Internet	4,38
	Intranet	4,25

The next section is the discussion section where the author will discuss the result from this section holistically and relate it with other research and theories.

5. Discussions

Based on the answer to the 1st main question, "Which type of Metaverse do you think Mixed Reality belongs to? there are multiple answer popups due to the respondents having their perspectives on the questions. According to Table 7, there is a 14% answer with Mirror World/Digital Twin. This is because Mixed Reality in machinery vocational schools is mainly to learn an engine of something. To learn a particular engine, there should be a physical object that will be digitalized in Microsoft HoloLens or any mixed-reality device. If the physical systems must exist, then it makes perfect logic that there be a mirror world, also known as a digital twin. Because of the existence of physical objects, it will make the learning outcomes as accurate as possible compared with learning with a real physical object. On the other hand, learning something with Mixed Reality systems is not always based on the physical object, it could be based on the concept or idea that it is not physical (Speicher et al., 2019).

43% of the results agree that Mixed Reality systems should fall under the Augmented Reality type of metaverse. This is also understandable because even though mixed reality is a combination of virtual reality and augmented reality, there are also understandings that say that mixed reality is AR 2.0 because people can still see their surroundings (Coquillart et al., 2011), but saying mixed reality is AR 2.0 is not scientifically proven. The last 43% said that mixed reality is not part of any metaverse type. The general theory of mixed reality is as defined by Kim et al., "mixed reality" (mixed reality) is the process of fusing the actual and virtual worlds to create new landscapes and representations in which digital and physical goods live and interact in real-time. Mixed reality (mixed reality) is a blend of the real and virtual worlds, unlike virtual reality (VR), which isolates users from the outside world (H. zhi Hu et al., 2019). mixed reality is not limited to one or the other but rather exists in a third dimension. Using mixed reality, students may soon be able to participate in engaging courses without ever leaving their homes. We the authors are more towards this point, that mixed reality should be the new type of metaverse called Mixed Reality because if we look at the components list, the metaverse components are a lot more than any other metaverse type components. After all, it's a combination of 3 metaverse types, Augmented Reality, Mirror World/Digital Twin, and Virtual World.

Question 2 is "Which type of metaverse is suitable for machinery vocational schools to make the teaching and learning process better?" during the interview all of the interviewees 100% agree that the machinery vocational schools must start using mixed reality technologies for teaching and learning. The authors' previous studies suggest that using mixed reality in the classroom has numerous positive effects, including improved learning engagement, increased interaction, higher student motivation, more effective teaching and learning, enhanced learning outcomes, and the opportunity for students to gain valuable hands-on experience. Because each advantage will have knock-on effects in other parts of education, they are all interconnected (S. P. Suryodiningrat et al., 2021). A mixed reality will have more beneficial effects on the educational experience for both teachers and students. According to the findings of the research review, mixed reality will be useful in the classroom for its many positive effects on education. Because of that reason, all of the interviewees consistently agree that the suitable metaverse for the machinery vocational schools is the same as they think the mixed reality metaverse type. The same results as the previous question, we have 14% agreeing on Mirror World, 43% on Augmented Reality, and the last 43% on Mixed Reality as the new type of Metaverse due to the combination of the list of components and 3 metaverse types.

The last question is "What are the basic components (hardware, software, or support) that must exist for Metaverse-based Mixed Reality for Machinery Vocational Schools?". There are 3 different categories for this question, hardware, software, and supporting components. In the first category, which is hardware, all of the interviewees agree that the Microsoft HoloLens is a must hardware component. Microsoft HoloLens comes out as a top result (n=7). They were followed by smartphones, tablets, and servers with the same volume (n=1). This is because the capabilities of mixed reality, in this case, Microsoft HoloLens, can be viewed with other devices such as smartphones and tablets. These 2 devices can view the activity but cannot interact directly. The server can be seen as the hardware component but can be viewed as the supporting component as well. The content dominates the result from the second category. According to Suryodiningrat et al. (2023), among other difficulties, content development stood out the most, as the most time-consuming component was associated with creating the robust and complicated content necessary to fully use the potential of mixed reality (S. P. Suryodiningrat et al., 2021). Creating content that takes full advantage of a mixed reality's features while still conforming to the course outline and inspiring student interest and interdisciplinary exploration is of paramount importance (Antoniou et al., 2017). As was previously indicated, the TPACK framework can be used to create effective content. Teachers can use the TPACK framework to reflect on how their subject-specific and pedagogical expertise might inform and improve their use of technology in the classroom. Teacher knowledge, pedagogical stance, and the integration of technology into instruction constitute the TPACK framework (Niess, 2011). For in-depth and long-term knowledge acquisition, see "Technology-enhanced Content Knowledge" (TCK) (Listiawan et al., 2018). The apps or content of the system must support experiential learning and must be engaging to improve the student's motivation, therefore they must line up with the syllabus, learning scope, learning objectives, and learning outcome. The Technology Pedagogy and Content Knowledge (TPACK) framework provides significant direction for creating content in mixed reality-based education (Herring et al., 2016). TPACK underscores the convergence of technology knowledge, pedagogical knowledge, and content knowledge, underscoring the significance of skilfully integrating these domains to enrich learning experiences. Within the realm of mixed reality, TPACK guides the design process by ensuring that educators possess a comprehensive understanding of how to utilize the distinct capabilities of mixed reality technologies to enhance educational objectives (Koehler & Mishra, 2013). This understanding takes into account the specific subject matter being taught and the instructional methodologies being employed. This paradigm promotes the idea that educators and instructional designers should not just prioritize the technical features of mixed reality technologies, but also think about how these tools may be utilized to create valuable learning experiences that are in line with curricular goals and effectively engage learners. By integrating TPACK concepts into the creation of mixed reality-based educational content, developers can construct immersive and interactive learning environments that promote profound comprehension, analytical reasoning, and cooperation among students.

The next one is Microsoft Dynamics 365 Remote Assist on a HoloLens, HoloLens 2, Android, or iOS smartphone enables technicians to work collaboratively from multiple places to achieve more efficiency. Give students the tools they need to get answers quickly. Using mixed reality and mobile devices for heads-up video calling, students can collaborate, learn, or get help from distant partners. Allow on-site and off-site training to work together in learning (*Overview of Dynamics 365 Remote Assist - Dynamics 365 Mixed Reality | Microsoft Learn*, n.d.). Followed with Microsoft Mesh is a system for facilitating cooperative virtual-reality adventures. It allows for more seamless communication and a shared sense of presence amongst distant and hybrid teams. To facilitate recruit onboarding, training, team building, and other similar activities (*Microsoft Mesh Overview | Microsoft Learn*, 2023). The platform allows businesses to design unique, interactive environments that foster fresh forms of collaboration and integrated with business intelligence (Hayardisi et al., 2018). Avatars and spatial audio can help your workforce feel more connected and engaged than ever before, elevating their experiences beyond the constraints of the real world. The last category is the supporting component. To support collaboration, using mixed reality, students can overcome their biases and gain new insights into the world around them. Using this innovative technology, you may set up a collaborative learning environment and provide students with access to previously inaccessible opportunities. In addition, this technology enables novel forms of immersive cooperation amongst students of different institutions and across industries (*HoloLens 2 Brings New Immersive Collaboration Tools to Industrial Metaverse Customers - Source*, 2022).

The incorporation of mixed reality has the potential to profoundly transform teaching techniques, student involvement, and educational achievements. Mixed reality combines virtual and physical surroundings to provide immersive learning experiences that accommodate various learning methods and preferences. Teachers can employ this technology to generate interactive simulations, virtual laboratories, and 3D visualizations, offering students practical learning experiences that were previously unattainable. This dynamic methodology not only improves understanding but also encourages inquisitiveness and innovation among students. In addition, mixed reality enables customized learning experiences, enabling students to investigate topics at their speed and degree of comprehension (Allcoat et al., 2021). This personalized approach fosters enhanced involvement and drive, resulting in enhanced educational achievements (Ogunseiju et al., 2023).

Moreover, the collaborative functionalities in mixed reality settings permit students to collaborate irrespective of their geographical location, fostering the development of cooperation and communication skills that are crucial for success in contemporary society (Ens et al., 2019). The ongoing development of mixed reality has significant opportunities for its incorporation into educational environments. This integration has the potential to revolutionize the process of teaching and learning, enhancing interactivity, inclusivity, and effectiveness in education (Workman, 2018).

6. Conclusion

The gap between vocational school graduates and the industries still exists. Mixed reality is a technology that might help to reduce the gap because of the advantages of using mixed reality in teaching and learning. The top five advantages of a mixed reality in the classroom are as follows: Higher levels of student interest and involvement; greater opportunities for student and instructor collaboration; higher levels of student motivation; Improved teacher efficiency; Enhanced student achievement; and access to real-world learning scenarios. Mixed reality technology has become popular since Microsoft launched its first Mixed Reality device called HoloLens. Unfortunately, there has been little exploration of the potential of mixed reality in vocational education. After conducting interviews with eight respondents, we can conclude that Mixed Reality is suggested to be the new type of metaverse because the components of mixed reality combine 3 different metaverse types, Augmented Reality, Virtual World, and Mirror World/Digital Twin. The essential components of mixed reality have been finalized by using a questionnaire and Likert-Scale and the result is the combination of 3 metaverse types except for camera and visual-haptic feedback because it is unnecessary for the mixed reality system. This result has measured the reliability by using Cronbach’s alpha with a value of 0.935.

The primary obstacle is in the creation of content. Content development is essential as it allows us to utilize the capabilities of a mixed reality system while ensuring alignment with the curriculum. Moreover, the content must be entertaining to motivate students and broaden the scope of learning. The second obstacle in utilizing mixed reality systems is the nascent state of the hardware due to its recent emergence, while the other problem is in the field of pedagogy. Pedagogy refers to the scientific and artistic study of education and learning theory. The term 'pedagogy' originates from ancient Greek and denotes a person who guides and instructs youngsters. Pedagogy is the deliberate and systematic approach that a teacher employs to facilitate the comprehension and learning of students. The process begins with the preparation of content and the determination of how it will be presented or delivered to the learner.

The practical contribution of this is to provide the fundamental elements of Mixed Reality that will assist individuals in creating or employing the mixed reality system for any purpose. They would know the essential factors or arrangements depending on the given inventory of crucial aspects. The author suggests that the inclusion of the Mixed Reality system in the curriculum of machinery vocational schools, along with governmental support, will enhance learning experiences and engagement, ultimately improving the competency level of graduates. Future research should focus on how Artificial Intelligence (AI) and Machine Learning (ML) can be equipped to help students learn and have better experiences.

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