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Sustaining STEAM Education and Creativity through Metaverse Applications: A Systematic Review (2019-2023)

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Abstract

The advancements in blockchain, virtual reality technologies and marketing techniques of social media companies have made Metaverse a mainstream concept. With its high immersive, engagement, and interactivity, it has gained recognition which prompts scholars and educators to investigate its possibilities in numerous educational disciplines, including its potential in facilitating life and experiential learning, innovation, and creativity in STEAM education. Numerous articles have vastly reviewed the educational use of Metaverse, however, reviews focused on Metaverse in both STEAM Education and creativity are limited. Hence, this paper attempts to systematically focus on the recent findings of Metaverse applications in STEAM Education and creativity. Using the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) 2020 guide-lines, 20 articles from 2019 to 2023 were extracted and analysed through two databases: Google Scholar and Educational Resources Information Centre (ERIC), considering the exclusion and inclusion criteria. Overall, the articles reviewed showed that Metaverse applications are favoured in a variety of art disciplines in STEAM classrooms as Metaverse provides numerous practical, convenient, applicable, and easily accessible features for digital aesthetic presentation, developing 21st-

century skills, encouraging interaction, engagement, and participation among language learners, improve and enrich language learning, and foster creativity in various aspects. However, the setbacks of Metaverse applications are addiction, high cost, and insufficient training. The findings reveal the gaps in research on Metaverse applications in STEAM Education and creativity. Therefore, the current literature suggests that future research should help widen the exposure of integrating Metaverse applications into STEAM Education and creativity.
Keywords: Creativity, Metaverse, STEAM Education, Systematic Literature Review

Introduction

The rapid evolution and advancement of technology which bring out Metaverse have sparked a revolutionary shift in the 21st-century education world and from the aspects of creativity. This significantly impacts our daily lives, gradually revolutionising us and making technology and creativity necessary to ensure life's sustainability. This leads to the emergence of the buzz words, which are “Metaverse” and “STEAM Education” in the field of educational technology. It offers boundless opportunities for exploration, collaboration, and innovation, making it an ideal medium for integrating Science, Technology, Engineering, Arts, and Mathematics (STEAM) education (Jantakun et al., 2021). Immersing students in virtual environments provide a hands-on approach to learning, enabling them to engage with complex concepts and experiments. Through virtual simulations and interactive experiments, students can explore scientific phenomena, design architectural structures, experiment with coding, or create digital artwork. These immersive experiences enhance their understanding of STEAM subjects in language learning (Hashim & Yunus, 2018) and foster critical thinking, problem-solving, and creativity (Ning et al., 2023).

The Metaverse is introduced as a collective virtual shared space which provides an immersive and interactive platform that transcends physical limitations through 4 aspects: augmented reality, lifelogging, mirror worlds, and virtual worlds (Lin et al., 2022). Since Neal Stephenson wrote about Metaverse in his book Avalanche in 1992, the Metaverse had transformed the world in various fields such as remote working areas, marketing and economics, entertainment and also education (Yang & Zhu, 2023). Metaverse active users have reached over 42 million since 2019, whereby the popular platform created are Second Life, Open Simulation, Minecraft, Fortnite, Roblox, Sandbox and Decentraland (Rospigliosi, 2022). There are four main types of Metaverse which are: Augmented Reality (AR), Virtual Reality (VR), Mix-Reality (VR) and Artificial Intelligence (AI). Therefore, Metaverse uses augmented reality technologies to immerse users in the real world, uses digital twin virtual technology to create a mirror image of the real world, uses blockchain technology to build the economic system and uses artificial intelligence to interact with others as well as edit and produce content in the virtual world (Saritas & Topraklıkoğlu, 2022).

A rapidly developing nation, Malaysia, focuses on a knowledge-based economy and technological advancements, which stands to benefit from harnessing the potential of the Metaverse in education. The utilization of the Metaverse in STEAM education has gained attraction in diverse educational settings, ranging from primary schools to higher education institutions. It can provide access to high-quality STEAM resources and experiences, bridging the gap between urban and rural areas (Yaacob et al., 2019). Additionally, the Metaverse can facilitate personalized and adaptive learning, catering to the diverse needs of students. the metaverse can facilitate the creation of virtual worlds where students can design and build complex structures, allowing them to understand engineering principles through hands-on

experiences (Saritas & Topraklıkoğlu, 2022). However, implementing the Metaverse in Malaysia requires addressing challenges like infrastructure, curriculum integration, and stakeholder collaboration (Yaacob et al., 2019). Besides, prioritizing reliable internet access, aligning with educational goals, and fostering collaboration among institutions, government, and tech providers are essential for a strong Metaverse-driven STEAM education framework (Saritas & Topraklıkoğlu, 2022).

To date, numerous studies have highlighted the potential of the Metaverse to enhance students' engagement, motivation, and knowledge retention as well as in other subjects. However, while the global literature provides valuable insights into the integration of the Metaverse in STEAM education and creativity, there is a scarcity of research exploring its implementation and impact in the STEAM education and creativity context. Hence, this paper shall shed light upon the recent findings of Metaverse applications mainly focusing on both STEAM education and creativity contexts. This paper shall answer the following questions:

RQ1: What Metaverse applications are used in supporting STEAM education and creativity?
RQ2: What are the impacts of applying Metaverse in STEAM education and creativity?

Emergence of Metaverse

Recently, the Metaverse has been gaining significant attention as a potential evolution of the Internet, promising a new immersive digital realm where users can interact, create, and explore (Zonaphan et al., 2022). The Metaverse converge multiple technologies that encompass the physical world and virtual reality, through Augmented Reality (AR), Virtual Reality (VR), Artificial Intelligence (AI) and Mix-Reality, thus enabling multifaceted interactions in the virtual world (Mystakidis, 2022). Augmented Reality (AR) is the only technology that connects physical reality to virtual reality, allowing real and virtual objects to interact with one another (Alkhabra et al., 2023). Virtual Reality (VR) is stated to be a technology which combines computer and sensor technology with multidisciplinary knowledge to help users explore and understand nature through digitalisation (Li et al., 2019). On the other hand, Artificial Intelligence (AI) is a technology that leverages data analytics and cognitive computing to interpret machine-learned discoveries of hidden patterns in data to enhance learning (How & Hung, 2019). The main characteristics of Metaverse are a strong focus, broad sensory engagement, and low latency, thus helping users to feel fully immersed in the virtual world.

The emergence of the Metaverse presents both opportunities and challenges for Malaysia. The Metaverse could create new industries and job opportunities in terms of economic potential (Hadi, 2023). It also has the potential to disrupt traditional sectors and spawn innovative businesses physically and virtually. Malaysia hosts a vibrant digital eco-system and tech-savvy population, which become a hub for Metaverse-related activities, fostering entrepreneurship, attracting investments, and driving economic growth. Furthermore, the Metaverse offers educational potential, enabling immersive and interactive learning experiences to enhance digital literacy in Malaysia (Yunus et al., 2013). Seamless and immersive experiences enable users to engage with digital environments, socialise, play, learn and collaborate with others, and also gain access to a wide range of services and content (Mystakidis, 2022). It could revolutionize education by providing virtual classrooms, simulations, and collaborative spaces, enhancing access to quality education, and promoting digital skills among Malaysian students (Arif et al., 2020).

STEAM Education and Creativity

STEAM education, an extension of STEM (Science, Technology, Engineering, and Mathematics), integrates the arts into the curriculum, emphasizing the development of both technical and creative skills (Ning et al., 2023). STEM education primarily focuses on technical skills, while STEAM education incorporates the arts to foster both convergent and divergent thinking. The addition of the arts introduces elements of creativity, imagination, and design thinking into the learning process, encouraging students to think critically, solve problems, and express their ideas in innovative ways (Aguilera & Ortiz-Revilla, 2021). In terms of language in the arts field, Metaverse can help students widen their vocabulary (Yunus et al., 2016) which widens their language writing skills (Yunus et al., 2013) By nurturing creativity, STEAM education equips students with the skills necessary to thrive in a rapidly evolving, technologically driven world (Yunus, & Sukri, 2017). Besides creativity, STEAM education that in-corporates dynamics between teachers and students with multidisciplinary learning and knowledge application shall also deepen and widen students' learning experiences and motivation (Hashim et al., 2016; Yunus & Abdullah, 2011).

In the Malaysian education landscape, there is a growing recognition of the im-portance of creativity and innovation in preparing students for the future. The government has made efforts to integrate creativity into the curriculum, aligning with the principles of STEAM education (Foen, 2022). Malaysia aims to cultivate a generation of students who possess both technical proficiency and creative thinking abilities, enabling them to contribute to the country's socioeconomic growth and development. STEAM education holds promise for Malaysia in various ways. By embracing STEAM principles, Malaysian schools can nurture well-rounded individuals who possess a combination of technical skills, critical thinking, and creativity (Foen, 2022). This interdisciplinary approach can enhance students' problem-solving abilities, communication skills, and adaptability, enabling them to thrive in a rapidly changing global economy. Moreover, STEAM education empowers students to explore their passions, express their unique perspectives, and contribute to the cultural and creative industries, which are important drivers of Malaysia's economic growth (Mubin & Thiruchelvam, 2023).

Metaverse Integration in STEAM Education and Creativity

In the education field, the Metaverse holds promises for enhancing STEAM education and fostering creativity. The Metaverse can provide immersive and interactive experiences that facilitate STEAM learning. Through virtual simulations and environments, students can engage in hands-on activities, experiments, and problem-solving scenarios (Zonaphan et al., 2022). Experiential learning approaches in STEAM learning can enhance students' understanding of complex STEAM subjects and promote critical thinking and problem-solving skills. The Metaverse can bridge the gap between theory and practice by enabling students to apply their knowledge in realistic contexts (Ayiter, 2011).

In a virtual Metaverse, students can collaborate with peers, participate in project-based learning, and even interact with professionals and experts from various fields. This interdisciplinary collaboration fosters creativity and innovation as students integrate their knowledge and skills from different domains to solve real-world problems (Aguilera & Ortiz-Revilla, 2021). By experiencing the practical application of STEAM concepts in the metaverse, students can develop a deeper appreciation for these subjects and their relevance in the world. The application of the Metaverse in STEAM education and creativity aligns with Malaysia's aspirations to develop a knowledge-based economy (Huei et al., 2021). Malaysia

has been actively promoting STEAM education initiatives to equip its workforce with the necessary skills for the digital age. By incorporating the metaverse into STEAM education, Malaysia can leverage technology to enhance the teaching and learning process, inspire creativity, and cultivate a future-ready workforce. The Metaverse can serve as a catalyst for innovation and entrepreneurship, as students gain exposure to emerging technologies and develop the skills required in the Fourth Industrial Revolution (Aguilera & Ortiz-Revilla, 2021).

Methods

Using the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) 2020 guidelines for its high validity in collecting, organising, and analysing articles for systematic review, this systematic literature review attempts to analyse and identify the current trends of Metaverse applications in STEAM education and creativity contexts encompassing the three stages in reference to the phases from Khan (2003), which are the identification phase, screening phase and included phase.

Phase 1: Identification Phase

Publications were searched, retrieved, and selected through these two databases: Google Scholar and Educational Resources Information Centre (ERIC). Google Scholar was chosen as it is a free web-search engine that is known for its wide and organized research track which provides historical trends in research, promotes meta-analytic studies and bridges social media and scholarly research. On the other hand, ERIC was chosen as it has also been tested as an academic search system which is fit to prove the synthesis in systematic reviews through Boolean operators.

Table 1
Search string used based on databases

Databases	Search Strings
Google Scholar	"metaverse*" and "virtual reality*" and "augmented reality*" and "artificial intelligence*" and "STEAM education*" and "arts education*" and "creativity*"
ERIC	"metaverse*" and "virtual reality*" and "augmented reality*" and "artificial intelligence*" and "STEAM education*" and "arts education*" and "creativity*"

After heedful contemplation of the results of removing potential search terms, these search terms were listed and identified as being the most instructive to retrieve information for this paper: metaverse, virtual reality, augmented reality, artificial intelligence, STEAM education, arts education, and creativity. Quotation marks were also used to search for those keywords and phrases. Keywords or phrases related to Metaverse ap-plications in STEAM education and creativity were meticulously formed and listed in Table 1 to gather entries on articles through Google Scholar and ERIC.

Phase 2: Screening Phase

The titles, abstracts and citations of academic journal articles were fully screened, read, and studied thoroughly by these two search systems which then were screened for relevancy. This is to determine the validity of the academic journal articles for this study. The complete texts of articles were scanned to see whether they matched the inclusion requirements if the abstracts did not contain ample information. The following inclusion and exclusion criteria in Table 2 were formulated after searching and gathering the literature through Google Scholar and ERIC. Irrelevant studies or articles were excluded by strictly following the exclusion criteria in Table 2.

Table 2
Inclusion and exclusion criteria.

Criteria	Inclusion	Exclusion
Year of Publications	2019 – 2023	< 2019
Type of Articles	Academic journal articles	Books, Conference Proceedings, Reports, Direct Links
Language	English	Non-English
Focus	Relevance with Metaverse applications in STEAM education and creativity	Irrelevant with Metaverse applications in STEAM education and creativity
Perspectives	Language learners, teachers, educators	Non-language learners, parents

To acquire the eligibility of the articles, the search strategy solely limits and focuses on the inclusion criteria based on Table 2. Firstly, the timeframe of the literature search is limited to 2019–2023 to provide an overview of the most recent research in this area. Secondly, only published academic journal articles are considered for this systematic re-view through both databases. Thirdly, academic journal articles should only be written in English for better understanding purposes. Fourthly, the relevance of the journal articles requires the examination of publications on Metaverse applications in STEAM education and creativity. Lastly, articles on language learners and educators are the targeted group of people to be reviewed.

Phase 3: Included Phase

The included articles are recorded in the PRISMA 2020 flow diagram. Hence, the lists of articles were finalised and listed in this stage. The whole procedure for this systematic review is completed and recorded based on the PRISMA Flow Diagram in Figure 2 below.

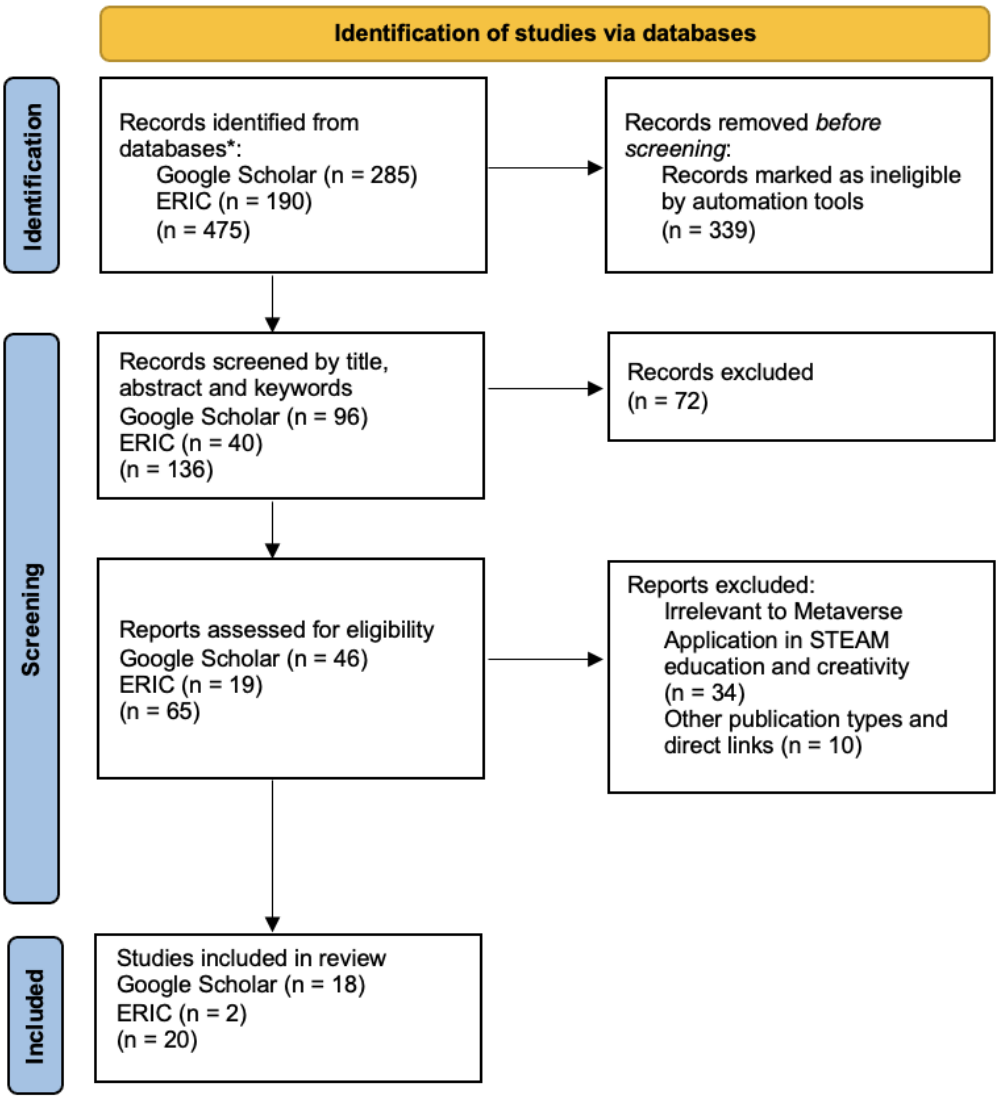

Figure 2: PRISMA flow diagram.

Based on Figure 1, Google Scholar generated 285 documents while ERIC generated 190 documents totalling up to 475 documents using search strings and retrieval strategies. The documents were further evaluated by only including publications from 2019 to 2023, hence 339 documents were removed, leaving 136 documents on the list. While screening through the titles, abstracts, and keywords for the second round of screening, another 72 documents were removed from both databases, leaving 64 documents on the list. Besides that, another 34 documents were removed as those documents were irrelevant to Metaverse Application in STEAM education and creativity contexts while 10 documents were removed as those were not open-access documents and of other publication types. Thus, the final screening showed that only 20 articles were eligible for this systematic review.

Data Analysis

These are the selected articles for this systematic review. Using Mendeley, a Reference Management Software, the 20 selected articles are exported and organised easily for this paper. The details of the 20 articles are summarised as shown in Table 4 based on the authors, countries, the focus of contexts, types of Metaverse used and impacts on STEAM education

and creativity. Several research articles showed data specifically from tertiary education institutions (Yang & Zhu, 2023; Ricci, 2023; Saito, 2023; Su et al., 2022; Soroko, 2021; Jantakoon, et al., 2019), high schools (Alkhabra, 2023; Han, 2022; Jesionkowska, 2020], and primary schools [Lee & Hwang, 2022; Girmen, 2019].

Table 4
Summary findings of the articles reviewed.

	Authors/ Years	Countries	Focus of Context	Metaverse Used	Impacts on STEAM	Impacts on Creativity
1.	Alkhabra, et. al. (2023)	Saudi Arabia	Language Arts	AR: HP Reveal	Promotes engagement and collaboration, better understanding in learning	None
2.	Fitria, (2023)	Indonesia	Liberal Arts	AR & VR	Develop engagement, enhance knowledge	None
3.	Hadi, (2023)	Indonesia	Language Arts	NFT comics: Comic Life	3D stories in developing reading and writing skills	Develop creative writing
4.	Yang & Zhu (2023)	China	Visual Arts	Metagame: Xirang	Promotes active learning, Develop 21st-century skills	Promotes brainstorming ideas
5.	Rahim & Rahman (2023)	Malaysia	Performing Arts	VR: Spatial.io	Develop knowledge & engagement	Promotes authenticity
6.	Ricci et. al. (2023)	Italy	Visual Arts	Mix reality: Unity Engine	Develop 21st-century skills	Develop creativity
7.	Saito (2023)	Japan	English speaking Lesson	VR: Immerse	Lower speaking anxiety foster HOTS skills	Develop creativity
8.	Sudarmanto & Ismail (2023)	Indonesia	Visual Arts	AR	Supports understanding, develop aesthetic education	Develop creativity

9.	Tripkov (2023)	Macedonia	Visual Arts	VR rooms	Promotes engagement and collaboration, Develop five senses	Develop creativity
10.	Su et. al. (2022)	Taiwan	Language Arts	AR flashcards	Develop language knowledge & motivation, connect language with everyday life	Develop creativity
11.	Han (2022)	Korea	Culture Arts	AR & VR: Google Earth, Arts & Culture	Develop 21st-century skills, Expands cultural thinking	Expressing creatively
12.	Kang et al. (2022)	Korea	Visual Arts	Roblox	Acquire knowledge, Improve art production	Develop creativity in digital art
13.	Lee & Hwang (2022)	Korea	Language Arts	VR textbooks	Develop 21st-century skills	Design VR learning spaces
14.	Lin & Liao (2022)	Taiwan	Musical Arts	AI: EarMaster's Tool	Promote AI music therapy art & literature education	Develop inspiring performances
15.	Soroko (2021)	Ukraine	Visual Arts	Metaclassroom	Expands knowledge systems	None
16.	Zhang et. al. (2022)	China	Cultural Arts	Mix-reality: LiDAR scanner FARO	Enhance understanding on cultural heritage	None
17.	Jesionkowska et. al. (2020)	United Kingdom	Visual Arts	AR: Microsoft HoloLens	Develop artistic, technical, and 21st-century skills	Develop artistic skills

18.	Kong (2020)	China	Modern Arts	AI	Improve intelligent art teaching	Enhance artistic experience
19.	Girmen et. al. (2019)	Turkey	Language Arts	VR Storybook	Develop writing skills & motivation	Foster creative writing
20.	Jantakoon et. al. (2019)	Thailand	Storytelling	Mix-reality	Enhance deeper learning	Forster artistic & creative expression

Results

As this paper aims to provide the current trends of the use of Metaverse applications in STEAM education and creativity, the results of the findings are shown in the related research articles on the topic. To answer the first research question of this paper, a quantitative data meta-analysis was done to fully capture the study landscape of the use of Metaverse applications in STEAM education and creativity. Subsequently, to answer the second research question of this paper, qualitative data were critically reviewed to identify the impacts of the use of Metaverse applications in STEAM education and creativity contexts.

RQ1: What Metaverse applications are used in supporting STEAM education and creativity?

Based on the 20 selected articles, there are 4 main types of Metaverse listed in the use of STEAM education and creativity: Augmented Reality (AR), Virtual Reality (VR), Artificial Intelligence (AI) and Mix-Reality. The data collected are listed and categorised in Table 5 below. This systematic review found that AR, VR and Mix-Reality applications are more popular in STEAM Arts education. It is also found that 7 articles reveal the use of Metaverse in Language Arts classrooms, another 7 articles focus on visual arts, while the remaining 4 articles fall under cultural arts and 1 article each for liberal arts and musical arts. 5 articles used AR applications in relation to STEAM Education, namely: HP Reveal, Comic Life, AR flashcards and Microsoft HoloLens. There are 6 articles that use VR ap-plications in relation to STEAM Education: Spatial.io, Immerse, VR Rooms, Roblox, Co-spaces Edu, Frame VR, and Go Animate. There are only 2 articles mentioning the use of AI in relation to STEAM Education, with only 1 article specifically stating the EarMaster's Tool in enhancing musical arts among students. A total of 7 articles listed stated the Mix-Reality applications use in relation to STEAM Education, namely: 3D stories, Xirang, Unity Engine, Google Earth, Google Arts & Culture, Cospaces Edu, Planets AR, LiDAR scanner FARO, ARToolKit, ArUco, and Vuforia SDK.

Table 5
Metaverse applications used in STEAM education and creativity.

Type of Metaverse	Names of Metaverse	Articles
AR	HP Reveal Comic Life AR flashcards Microsoft HoloLens	(Alkhabra et al, 2023) (Hadi, 2023) (Sudarmanto & Ismail, 2023), (Su et al., 2022) (Jesionkowska et al., 2020)
VR	Spatial.io Immerse VR Rooms Roblox Cospaces Edu, Frame VR Go Animate	(Rahim & Rahman, 2023) (Saito, 2023) (Tripkov, 2023) (Kang et al., 2022) (Lee & Hwang, 2022) (Girmen et al., 2019)
AI	EarMaster's Tool	(Lin & Liao, 2022) (Kong, 2020)
Mix-Reality	3D stories & AR images Xirang Unity Engine Google Earth, Google Arts & Culture Cospaces Edu, Planets AR, etc. LiDAR scanner FARO ARToolKit, ArUco, Vuforia SDK.	(Fitria, 2023) (Yang & Zhu, 2023) (Ricci et al., 2023) (Han, 2022) (Soroko, 2021) (Zhang et al., 2022) (Jantakoon et al., 2019)

RQ2: What are the impacts of applying Metaverse in STEAM education and creativity?
The advantages and disadvantages listed from the selected articles are themed and categorised in Table 6. 6 articles showed that Metaverse helps develop 21st-century skills, while 7 articles state its potential in promoting engagement and collaboration among users. Besides, it is specifically proven that Metaverse enhances cognitive skills in 8 articles, enhances language skills in 4 articles, and develops artistic skills in 4 articles. Metaverse is also stated in promoting active learning in article 4 while developing users' five senses in article 9. Metaverse helps develop cultural thinking as stated in articles 11 and 16, whereas music therapy is promoted through Metaverse in article 14. The dis-advantages of Metaverse in the application of STEAM Education are shown due to its high cost (9 articles), addiction among users (6 articles), and insufficient training (10 articles).

Table 6
Impacts of Metaverse in STEAM education.

Impacts	Themes	AR	VR	AI	Mix-Reality
Advantages	Develop 21st-century skills	(Jesionkowska et al., 2020)	(Saito, 2023), (Lee & Hwang, 2022)		(Yang & Zhu, 2023), (Ricci et al., 2023), (Han, 2022)
	Promotes engagement and collaboration	(Alkhabra et al, 2023), (Su et al., 2022)	(Rahim & Rahman, 2023), (Saito, 2023), (Tripkov, 2023), (Girmen et al., 2019)		(Fitria, 2023)
	Enhance cognitive skills	(Alkhabra et al, 2023), (Sudarmanto & Ismail, 2023)	(Rahim & Rahman, 2023), (Kang et al., 2022)		(Fitria, 2023), (Soroko, 2021), (Zhang et al., 2022), (Jantakoon et al., 2019)
	Enhance language skills	(Hadi, 2023), (Su et al., 2022)	(Girmen et al., 2019)	(Lin & Liao, 2022)	
	Develop artistic skills	(Sudarmanto & Ismail, 2023), (Jesionkowska et al., 2020)	(Kang et al., 2022)	(Kong, 2020)	
	Promotes active learning				(Yang & Zhu, 2023)
	Develop five senses		(Tripkov, 2023)		
	Develop cultural thinking				(Han, 2022), (Zhang et al., 2022)
	Promotes music therapy			(Lin & Liao, 2022)	
Disadvantages	High cost	(Alkhabra et al, 2023),	(Saito, 2023),	(Lin & Liao,	(Fitria, 2023), (Soroko,

		(Jesionkowska et al., 2020)	(Kang et al., 2022)	2022), (Kong, 2020)	2021), (Han, 2022)
	addiction	(Hadi, 2023), (Su et al., 2022)	(Rahim & Rahman, 2023), (Tripkov, 2023)		(Zhang et al., 2022), (Jantakoon et al., 2019)
	Insufficient training	(Alkhabra et al, 2023), (Hadi, 2023), (Sudarmanto & Ismail, 2023)	(Lee & Hwang, 2022), (Girmen et al., 2019)	(Lin & Liao, 2022), (Kong, 2020)	(Yang & Zhu, 2023), (Han, 2022), (Ricci et al., 2023),

From the articles listed, Metaverse is proven in promoting creativity among ap-plication users. It is seen that authenticity is promoted through Metaverse (6 articles). Besides, Metaverse enhances digital aesthetic presentation (4 articles). There are 6 articles stating that Metaverse does promote creativity generally. However, there are 4 articles which did not include the creativity element into their paper.

Table 7
Impacts of Metaverse in fostering creativity.

Impacts	Articles
Promotes authenticity	(Hadi, 2023), (Yang & Zhu, 2023), (Rahim & Rahman, 2023), (Jesionkowska et al., 2020), (Girmen et al., 2019), (Jantakoon et al., 2019)
Promotes creativity in general	(Ricci et al., 2023), (Saito, 2023), (Sudarmanto & Ismail, 2023), (Tripkov, 2023), (Su et. al., 2022), (Kang et al., 2022)
Enhance digital aesthetic presentation	(Han, 2022), (Lee & Hwang, 2022), (Lin & Liao, 2022), (Kong, 2020)

Discussion

Utilisation of Metaverse in STEAM Education and Creativity

The Metaverse has vastly integrated into our daily lives, thus integrating Metaverse into STEAM education, especially in terms of the language art aspect in ESL classrooms is practicable. To implement and encourage Metaverse in STEAM arts classrooms, educators and teachers can provide immersive and interactive virtual aesthetic environments through Metaverse applications, whereby students are able to conduct artistic experiments, explore artistic and language concepts, and simulate real-world scenarios through various forms of art (Su et. al., 2022; Sudarmanto & Ismail, 2023). Students are also able to conduct their learning autonomously through Metaverse (Yunus & Arshad, 2015) Professional guidance and facilitation from educators allow hands-on learning experiences in STEAM classrooms without the limitations of physical resources or safety concerns. Using AR in STEAM arts classes,

students can define their own virtual aesthetic and linguistic images and experiences respectively Tripkov (2023) as they effectively enhance aesthetic and linguistic knowledge to produce productive aesthetic and language ability (Yunus et al., 2016). The 3D virtual items provide meaningful and detailed information which enriches learning in classrooms (Alkhabra et al, 2023; Hadi, 2023; Sudarmanto & Ismail, 2023; Su et. al., 2022; Jesionkowska et al., 2020). Besides, Metaverse enables students to engage and collaborate on creative projects and designs in virtual spaces. They can work together on art, music, architecture, or language arts projects, fostering creativity and teamwork. This shared virtual space can enhance the exchange of ideas and allow for iterative design processes (Alkhabra et al, 2023; Su et. al., 2022; Rahim & Rahman, 2023; Saito, 2023; Tripkov, 2023; Girmen et al., 2019; Fitria, 2023). Metaverse can link students with professionals and mentors from around the globe.

Through VR Rooms and Roblox (Tripkov, 2023; Kang et al., 2022), guidance, feedback, and mentorship from professionals can be received in STEAM fields, expanding their cognitive and art knowledge as well as networking opportunities. Moreover, VR is proven effective in recreating historical landmarks, natural environments, and cultural sites, allowing students to take virtual field trips to places that may be otherwise inaccessible (Rahim & Rahman, 2023; Saito, 2023; Tripkov, 2023; Kang et al., 2022; Lee & Hwang, 2022; Girmen et al., 2019). This promotes active learning as they can explore ancient civilizations, dive into the depths of the ocean, or visit far-off planets, providing rich educational experiences, instead of teachers making students sleepy with long winding stories in class (Yang & Zhu, 2023). The metaverse offers a platform for students to showcase their work and talents to a global audience through a variety of Mix-Reality applications. They can create virtual art galleries, participate in virtual science fairs, or present their projects in immersive virtual environments, promoting creativity and recognition (Fitria, 2023; Yang & Zhu, 2023; Ricci et al., 2023; Han, 2022; Soroko, 2021; Zhang et al., 2022; Jantakoon et al., 2019). Lastly, by merging the physical and virtual worlds, the Metaverse can enhance STEAM education through Artificial Intelligence. Students can use AI devices to overlay digital information, models, or instructions onto the real world, making complex concepts more tangible and interactive (Lin & Liao, 2022; Kong, 2020).

Impacts of Metaverse in STEAM Education and Creativity

Advantages of Metaverse in STEAM Education and Creativity

The Metaverse offers a multitude of opportunities towards its implementation in STEAM education as well as fostering creativity among 21st-century students. Firstly, Metaverse has made digital aesthetic presentations more accessible and inclusive. 3D presentation in STEAM classrooms allows immersive and interactive experiences that go beyond traditional teaching and learning classroom presentations. Teachers are able to create visually stunning virtual 3D classroom materials, such as models, textures and animations to engage or captive their students as those materials can leverage various senses of the audience (Alkhabra et al, 2023; Hadi, 2023; Sudarmanto & Ismail, 2023; Su et. al., 2022; Jesionkowska et al., 2020). Students conducting STEAM projects in Arts classrooms can test different visual and interactive elements, gather feedback from peers and educators, and make iterative improvements to their digital aesthetic presentations. This iterative approach fosters creativity and pushes students to refine their work based on feedback and personal reflection. Besides, the immersive nature of the metaverse can enhance students' problem-solving, critical thinking, and collaboration skills, which are vital in STEAM education (Jesionkowska et al., 2020; Saito, 2023; Lee & Hwang, 2022; Yang & Zhu, 2023; Ricci et al., 2023; Han, 2022). Virtual environments can offer interactive challenges and simulations that promote hands-on

learning experiences. Moreover, the Metaverse allows students to collaborate and communicate with peers, experts, and educators from around the world. Such collaborations can promote interdisciplinary learning and provide opportunities for students to work on STEAM projects together (Alkhabra et al, 2023; Su et. al., 2022; Rahim & Rahman, 2023; Saito, 2023; Tripkov, 2023; Girmen et al., 2019; Fitria, 2023). The Metaverse can provide equal access to educational resources and experiences regardless of geographical location or physical abilities. Students from diverse backgrounds can engage in STEAM learning and access virtual environments that simulate real-world scenarios for experimentation and exploration. Furthermore, the Metaverse can adapt to individual learning styles and paces, offering personalized learning experiences which develop students' cognitive skills in various personalised ways (Alkhabra et al, 2023; Sudarmanto & Ismail, 2023; Rahim & Rahman, 2023; Kang et al., 2022; Fitria, 2023; Soroko, 2021; Zhang et al., 2022; Jantakoon et al., 2019). STEAM education can benefit from tailored virtual environments and activities that cater to student's specific interests and abilities, for instance promoting music therapy for relaxation before learning (Lin & Liao, 2022).

Judging from the aspects of creativity, the Metaverse can serve as a platform for students to express their creativity. By enabling them to design and create within virtual spaces, the metaverse can support artistic expression, design thinking, and innovation in STEAM-related fields (Ricci et al., 2023; Saito, 2023; Sudarmanto & Ismail, 2023; Tripkov, 2023; Su et. al., 2022; Kang et al., 2022). The Metaverse allows individuals to express themselves in unique and creative ways (Hadi, 2023; Yang & Zhu, 2023; Rahim & Rahman, 2023; Jesionkowska et al., 2020; Girmen et al., 2019; Jantakoon et al., 2019). Through avatars, virtual spaces, and digital creations, people can showcase their authentic identities, preferences, and artistic styles. The Metaverse can create spaces that are inclusive and embrace diverse perspectives, backgrounds, and identities. The hands-on approach to learning promotes authenticity by allowing students to apply their knowledge in real-life contexts and develop skills that are relevant to their interests and future careers (Han, 2022; Lee & Hwang, 2022; Lin & Liao, 2022; Kong, 2020).

Disadvantages of Metaverse in STEAM Education and Creativity

Although Metaverse has become increasingly popular around the globe, including in the field of education, it is not without its challenges in executing it in various subject areas and educational institutions. The articles found mainly three obstacles in implementing Metaverse in STEAM education and fostering creativity among students. Firstly, the majority of the articles stated that Metaverse is seldom or not encouraged in using in STEAM classrooms due to insufficient training among educators and teachers (Alkhabra et al, 2023; Hadi, 2023; Sudarmanto & Ismail, 2023; Lee & Hwang, 2022; Girmen et al., 2019; Lin & Liao, 2022; Kong, 2020; Yang & Zhu, 2023; Han, 2022; Ricci et al., 2023). Not many teachers are flexible enough in keeping up with the latest digital teaching method in Web 4.0 Industrial Education. The 9 articles Alkhabra et al (2023); Jesionkowska et al (2020); Saito (2023); Kang et al (2022); Lin & Liao (2022); Kong (2020); Fitria (2023); Han (2022); Soroko (2021), concluded that in order to obtain suitable and of higher quality range of Metaverse applications, the education organisations or educational users have to pay a higher amount of payment to retrieve the virtual items needed. Besides, it is also stated that using Metaverse applications for learning may promote addiction to using the technology (Hadi, 2023; Su et. al., 2022; Rahim & Rahman, 2023; Tripkov, 2023; Zhang et al., 2022; Jantakoon et al., 2019).

Students may indulge in "Cyber-syndrome" due to the effects of excessive interaction with cyberspace if usage time is not well-managed.

Conclusions

In conclusion, this systematic review paper has successfully reviewed the current trends of the use of Metaverse in STEAM education as well as fostering creativity through the use of the PRISMA flowchart. With the application methods of PRISMA, the literature has been searched and analysed to reveal the trending use as well as the positive and negative impacts of the utilisation of Metaverse applications in STEAM education and creativity. Thus, the Metaverse is proven useful for fostering creativity and enhancing teaching and learning through the multiple positive impacts listed. The advantages found are mainly: digital aesthetic presentation, developing 21st-century skills, encouraging interaction, engagement, and participation among language learners, improving and enriching language learning, and fostering creativity in various aspects. However, Metaverse also faces its challenges through the execution process in the STEAM education field, which are high cost, addiction, and insufficient training. Nevertheless, the ad-vantages of Metaverse stand out more in supporting 21st-century STEAM teaching and learning with the indulgence of rapid technology. Besides, creativity is highly stated through the use of Metaverse applications.

The study presented in this paper is rather limited to conceptual knowledge review, hence more empirical studies on the use of Metaverse in STEAM education and creativity have to be done as much as possible. Based on this paper, it can be seen that Metaverse is still an ongoing developing teaching and learning tool which shows the need for more research to be done in order to have it fully implemented in classrooms and the education world. The works of literature reviewed showed that Metaverse in STEAM is still vastly used in Mathematics and Science subjects with the inclusion of the art element. Besides, most research is conducted in classrooms in other countries. Thus, as a Malaysian re-searcher, future research on Metaverse applications in STEAM education is greatly encouraged to include more vibrantly in the STEAM classrooms with English as the core element. As Metaverse is widely seen as the future of education, future research on the implementation of Metaverse in rural Malaysia STEAM classrooms, as well as inclusive and special education schools for the benefit of all students, thus also fostering equity in education.

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