A Concept Paper on Students' Acceptance of Spatial-Unity Metaverse for Learning Fundamentals of Computer Science

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ABSTRACT

The current progression of technology has led to the introduction of immersive learning tools that can be integrated into educational settings to redefine teaching and learning pedagogical approaches. Metaverse platforms are amongst the latest tool that incorporates both virtual and augmented reality experiences to provide real-time collaboration, and engagement and address specific challenges in understanding abstract concepts in learning. This concept paper focuses on the potential use and acceptance of metaverse platforms, specifically Spatial-Unity in providing an engaging space where students can understand abstract concepts within The Fundamental of Computer Science subject and explore the importance of understanding the acceptance of secondary school students in accepting this technology within specific subjects as their cognitive and developmental stages influence their learning preferences and engagement through the proposal of integrating the Unified Theory of Acceptance and Use of Technology framework (UTAUT). To better understand students' acceptance, important factors within the UTAUT framework such as hedonic motivation, performance expectancy, and facilitating conditions, are proposed. These factors may impact the overall acceptance of Spatial-Unity among secondary school students. The potential findings aim to identify research gaps within the acceptance of metaverse platforms and provide insights for educators, policymakers, and developers on how to enhance computer science learning and STEM education in general, improve equity in technological adoption, and foster innovative approaches to teaching abstract concepts.

Keywords—Metaverse, Acceptance, Secondary School Students, Computer Science, Learning

INTRODUCTION

The recent advancement in technology has led to significant improvements in many sectors such as commerce, entertainment, and education. Immersive technologies are among the recent technologies that can be integrated into the educational setting to provide potential solutions for improving pedagogical challenges and better learning outcomes. Subjects such as Computer Science are commonly regarded as complex and abstract and students find it challenging to fully understand these concepts, especially within underrepresented groups [1] such as students from rural areas and specific subjects that are underexplored. These challenges pose risks in enhancing experiential learning, to address these issues, the integration of technology shows valuable potential. Immersive platforms like metaverse learning spaces can potentially provide a better learning experience. Metaverse platforms are immersive platforms that can be found in the forms of 2D or 3D virtual spaces. It combines both virtual realities and augmented reality elements in real-time, allowing students to experience learning more engagingly and collaboratively, thus leading to deeper understanding [2].

Computer Science is a part of STEM subject that introduces learning materials that are often abstract and, therefore might be perceived as complex and challenging among learners. The delivery of abstract concepts such as data measurements within the Fundamental of Computer Science curriculum through methods that mainly rely on one-way communication in the forms of lecture-based lessons may fail to capture students' attention therefore resulting in difficulties in understanding these concepts more engagingly [3]. Heavily relying on this method can decrease students' ability to comprehend the concepts easily and reduce students' engagement, especially among learners who have cognitive barriers [4]. Without the integration of a more student-cantered

approach that engages students to explore through practical applications such as the use of interactive learning methods, worsens these challenges, contributing to inconsistent learning outcomes and reduced comprehension among students.

Interactive solutions in learning have become a necessary component in improving not only engagement but also comprehension and are seen as a crucial factor to be considered when designing pedagogical strategies to promote experiential learning [5][6]. Metaverse consists of various platforms such as Zepeto, Gather Town, Roblox, and Spatial.io that provide various unique characteristics ranging from simple features such as providing virtual spaces for collaboration or learning to integration of 3D models in Sketchfab and portals to other applications online. Metaverse consists of various platforms such as Zepeto, Gather Town, Roblox, and Spatial.io that provide various unique characteristics ranging from simple features such as providing virtual spaces for collaboration or learning to integration of 3D models in Sketchfab and portals to other applications online. The integration of metaverse platforms such as Spatial-Unity, provides an innovative approach to learning computer science. Elements like gamification can be added to make the learning experience more engaging and exciting where students are introduced to more student-centered learning materials such as the incorporation of elements that require students to complete a set of tasks while receiving immediate reward upon completion, can potentially aid in delivering theoretical concepts such as programming, data representation, and data measurement through a more modern and progressive approach as demonstrated by [7].

Immersive platforms have been proven to show promising results in making Science Technology, English, and Mathematics (STEM) complex concepts more tangible. A previous study leveraged the use of virtual reality in a workshop for teaching mathematic concepts and findings indicated positive results regarding learning performance [8]. Other STEM-related subjects, in particular, science courses also demonstrate similar positive results regarding retention and understanding of science concepts as presented by [9] where findings from the study acknowledged the potential of integrating gamified experience to aid better understanding among students. Therefore, the implementation of metaverse platforms such as Spatial-Unity are indeed potential immersive technologies that can enhance the overall learning experience and foster deeper understanding among learners and further exploration in other disciplines should be carried out to better understand the full potential of this learning tool.

The potential of metaverse technologies has shown promising educational learning outcomes across all levels including primary, secondary, and higher education. The acceptance of metaverse technologies has extensively been studied especially in higher educational and professional training like studies demonstrated by [10] and [11]. Both studies focused on the acceptance of metaverse technologies and identified factors such as performance expectancy and social influence as contributing factors to the acceptance of this technology. This indicates the importance of understanding factors that might influence the acceptance of metaverse platforms and the need to investigate how secondary school students accept this technology in learning. Though studies have explored its acceptance among higher education, very few studies have focused on age groups between 13- to 17-year-old students, especially focusing on particular subjects such as computer science. Therefore, this concept paper aims to address these gaps by exploring how metaverse platforms are used in education, the potential of Spatial-Unity metaverse platforms in enhancing learning outcomes in computer science subjects among secondary school students, and exploring contributing factors and research gaps related to students' acceptance of metaverse technology. This concept paper also aims to identify potential challenges, and current solutions and propose suggestions for future research to address the identified research gaps, hence providing a foundation for future research and practical applications of metaverse technologies in secondary education, particularly in STEM fields.

LITERATURE REVIEW

Metaverse

The term metaverse was derived from a novel, Snow Crash that explained about virtual spaces for individuals by Neal Stephenson in 1992 and since then has influenced various sectors such as business, social, and education [12][13]. Metaverse refers to the combination of virtual reality (VR) and augmented reality (AR) that allows users to gain immersive real-time experiences. The immersive potential that metaverse has to offer, makes the

digital space very interesting, accessible, and engaging suitable to use for collaboration or learning sessions. The metaverse environments can be accessed through multiple types of devices such as desktops, laptops, mobile phones, tablets, and headsets, ensuring flexibility and accessibility [14].

Leveraging the use of metaverse in education promises a shift from traditional learning approaches to a more unconventional way to better address learning challenges and potentially enhance engagement. The immersive features of metaverse technology allow students to visualize and explore complex topics interactively, and can potentially help to explain concepts within the STEM subjects. Previous studies related to metaverse platforms have shown significant improvements in areas such as comprehension and retention through the use of hands-on learning experiences and game-based approaches that can cater to diverse learning styles [15][16]. For instance, through the use of metaverse platforms, students can interact or create 3D models, engage in simulations of real-world scenarios, organize collaborations with other students regardless of geographical location, and nurture computational thinking, critical thinking, and problem-solving skills [17][18]. This shows that metaverse technology can be a powerful tool to improve interactivity, and engagement and offer a more personalized learning space, thus bridging the gap between theoretical knowledge and practical applications and improve learning experiences

Types of Metaverse Platforms Studied in Education

Metaverse technologies come in various types, like many other technologies that have been introduce before. Metaverse platforms are introduced in form of 2D platforms such as Gather Town and 3D platforms such as Zepeto and Spatial.io. These platforms come with unique features, advantages and limitations, that allow user to choose the exact metaverse technology that will be used according to the accessibility of devices, network connection, and educational purposes.

Spatial.io

The main focus of Spatial.io, a metaverse platform created by Anand Agrawala and Jinha Lee in 2017, was to integrate social and engaging experiences on the internet through the integration of interactive computer interfaces and augmented technology. Since the introduction of Spatial.io, it has been used to organize virtual spaces where users can collaborate for many purposes including immersive learning. The usage of Spatial.io has shown effective results in various subjects such as Physics, Mathematics, Religious Studies, and English [19][20]. Spatial.io unique features include the simplicity of creating user-friendly virtual spaces that can be created and used by novice users. The usability features such as in-built tools, clarity, and efficiency, enable students to engage with content flawlessly [21]

Recent studies have indicated that Spatial.io can aid in enhancing creativity, engagement, and learning outcomes, making it a promising tool for delivering complex educational content. [22] implemented the use of Spatial.io to aid in teaching a topic on disaster in a geography subject. By leveraging the 3D models, the author used these features to create a 360-degree environment and the use of avatars to ensure that students fully engage with the learning materials and virtually visit high-risk areas that pose as a hazardous environment, thus overcoming issues related to safety without compromising students learning experience. The integration of these features allows observations and analysis of real-life situations, therefore encouraging the development of critical thinking and practice of problem-solving skills in a controlled virtual environment. Spatial.io can also be used to educate students through emotional engagement through immersive storytelling as demonstrated by [23]. The researcher used immersive story-telling to explain historical events that occurred in the past by creating a personalized and engaging virtual space through the use of multimodal content and collaborative tools that can also aid in supporting diverse learning needs and styles.

Among the features of Spatial.io is the ability to address diverse learning styles through the integration of various learning content such as infographics, various audio formats, text, and 3D elements, and the integration of other learning tools on the web through the use of portals [24]. Additionally, the diversity of this metaverse platform, allows users to use it through multiple devices like laptops, mobile phones, and headsets, ensuring all stages of users from different backgrounds the chance to use it [25]. Therefore, the use of this platform as highlighted by researchers before, brings positive outcomes in improving the overall learning experience. While recent studies

have shown promising results, limited research has been carried out towards disciplines such as STEM education, specifically computer science curriculum. Discovering the potential of Spatial.io in these areas can contribute to the current gap between theoretical knowledge and practical application.

Unity

Compared to Spatial.io, Unity is a more complex platform that requires users to have coding knowledge to fully leverage its uses. It is a platform that is commonly used to create not only 2D and 3D virtual spaces but also used to create games, e-learning content, simulations, and animation. Originally developed as a professional-grade tool for game development, Unity has been successfully adapted for educational purposes, particularly in STEM disciplines and computer science. Unity supports both VR and AR applications and provides access to asset stores where developers can purchase or download pre-ready models, codes, and animation to aid in the development of the project. It also can be used across multiple development platforms such as Windows, macOS and WebGL and various devices including oculus and HoloLens, hence its strong features and flexibility allow educators to design immersive learning experiences tailored to specific curricular goals.

One of the strong features of Unity is the ability to integrate gamification elements into educational learning content, potentially making it more engaging and can enhance motivation to use it. Elements such as task-based challenges, tokens, and badges are among the features that can be added with the use of Unity. [26] studied the effectiveness of Unity by applying this platform to teach secondary school students coding through a game development activity. Findings indicated that learning to code with the use of this platform, encouraged the improvement of problem-solving skills and computational thinking among the students. The professional designing tools that were integrated into the platform made the learning process both engaging and enjoyable.

Besides the development of game-based platforms, Unity can be leveraged to create a visual representation of abstract concepts that are well-known throughout STEM subjects. The nature of abstract concepts can be challenging for students to comprehend and visualize, therefore the creation of 3D models through Unity can help in overcoming this issue as demonstrated by [27]. The study explored the use of a virtual world created through Unity, to interpret volumetric biological data, such as hyperstack images and point clouds. Findings indicated that students gained a deeper understanding of the concept through the use of Unity as it allowed a hands-on approach that differs from the traditional strategies.

Though Unity has many benefits to offer, however, its complexity makes as a challenge to fully integrate it, especially among novice developers or learners who are new to coding. To implement this platform, educators should be given ample time and enough training resources to understand how to apply the features effectively. However, the benefits and advantages of using Unity outweigh its downsides as it provides a solid platform for creating engaging, interactive, and immersive learning experiences that can be seen as a valuable tool for educators to use to improve students' learning outcomes.

Zepeto

Zepeto is a metaverse platform created by Naver Z Corporation that offers 3D models, avatars, and the ability to customize virtual worlds according to the developers' preferences. Introduced in 2018, this immersive tool also offers features that can help in enhancing learning outcomes and engagement among students. Previous studies in various primary school settings have shown positive results in supporting the language learning process, in particular, speaking skills and vocabulary development through the use of interactive and gamified learning experiences [28]. Zepeto features include a "built it" tool that can help in the creation of personalized learning spaces. Developers can add collaborative features such as virtual selfies and mini-games into the virtual space.

A recent study conducted by [29], leveraged the use of Zepeto to observe the effectiveness of its use in science subjects. Findings indicated that Zepeto significantly improved both their academic performance and interest in the subject. This is consistent with the findings from Lee, (2024) that the integration of multiple features such as interactive elements, visuals, and text improved students' engagement and satisfaction in online learning. Despite challenges such as user capacity limits and the need for structured integration into curricula, Zepeto represents a valuable tool for innovative teaching methods, particularly in immersive and gamified educational settings.

Gather Town

Gather Town is a 2D metaverse platform created by Philip Wang and Kumail Jaffer in 2020, to provide engaging virtual spaces that can be used particularly during the Covid-19 pandemic as a remote virtual space that organizations or teachers can use [31]. Among the unique features that Gather Town has to offer are the practicality of holding video conferences in an interactive 2D environment and real-time collaboration through interactive features. Gather Town offers tools where users can customize avatars and virtual classrooms according to preference or even mimic real-life spaces. This technology gained attraction, especially since the outbreak COVID-19 pandemic, and has been proven to retain engagement and motivation among students while offering a novel alternative when traditional online learning methods struggled to sustain interest [32].

Beyond the pandemic situation, Gather Town is used to enhance collaborative and educational experiences as indicated by [33] and findings suggested that this platform was effective for teamwork as it has the combination of social interaction and gamified features that make it more interesting. The unique features that allow users to move around the virtual space as opposed to video meetings such as Zoom and Google Meet are an added value. According to [34] the combination of blended laboratory activities with the use of Gather Town significantly increases students' collaborative skills. The study found that the combination of visual elements, interactive features, and ease of use contributed significantly to improving learning outcomes in both physics and biology education.

Therefore, studies indicate that Gather Town is indeed an effective tool to enhance the learning experience. The unique 2D features also allow smooth network connection compared to 3D platforms while offering social connection and gamified features to enhance engagement and enjoyment [35]. However, the challenges of this platform consist of the inability to produce 3D models that can aid in providing a more immersive appearance. Nevertheless, Gather Town's unique features, underscore the effectiveness of this metaverse platform to be used within the educational setting.

Metaverse Applications in STEM and Non-STEM Education

The use of various metaverse platforms has been carried out by researchers in an attempt to explore its potential within the educational setting including Science, Technology, English, and Mathematics (STEM) and non-STEM education. STEM subjects are usually connected to abstract concepts that are challenging to understand and the aid of visualization is needed in areas such as programming and data representation in computer science, medical procedures in healthcare, and chemical reactions in chemistry [15][16]. A study on STEM education was carried out through a Project Based Learning project with the integration of metaverse platforms by [36] which discovered that the immersive and interactive features significantly enhanced students' ability to understand scientific concepts and design skills. Another research carried out by [37] found similar results regarding the enhancement of visualization of architectural concepts, engagement, and teamwork among engineering students through the integration of metaverse in Building Information Modelling courses. These findings present the potential of metaverse platforms in aiding the comprehension, retention, and engagement of difficult subjects such as STEM subjects that can be beneficial in improving overall learning outcomes.

The implementation of metaverse platforms was also carried out for non-STEM subjects such as English language and history. A study by [38], discovered that the use of this technology improved students' understanding of historical events through spatial dimensions through the application of 3D visualization and audio elements to explain the historical events and structure of the Pantheon in Rome [39], in a study related to physical education also presented similar results regarding the integration of immersive and interactive features that enhanced students' engagement and motor skill learning, therefore demonstrating the potential of metaverse platforms in providing experiential learning not only among STEM subjects but also can be an effective solution for non-STEM subjects.

The integration of metaverse platforms has indeed shown promising potential in enhancing multiple disciplines in education and further research should be carried out on other subjects particularly the Fundamental of Computer Science Subject. This presents an opportunity to further explore metaverse technologies that can address the cognitive and engagement challenges in teaching abstract topics like data measurement. Though

metaverse technologies have been used widely as mediums of entertainment, however its adoption in educational settings may vary across multiple factors such as gender, age, and perception of this immersive technology. This indicates a gap that researchers can explore to understand factors contributing to the adoption of this technology to design a virtual environment that is not just enjoyable but also effective across diverse learner groups [40].

Benefits of Integrating Spatial-Unity

Spatial.io and Unity are both metaverse platforms that offer immersive, interactive, and engaging tools to be used in developing a customized virtual space. The integration of both platforms can be leveraged through the use of embedded toolkits that are specifically customized to allow the integration of immersive platforms. The use of Unity alone can be time-consuming and requires technical expertise. In comparison, the use of Spatial alone, too, possesses challenges as while it might be less time-consuming, this platform might lack the depth and complexity needed to create interactive features. By combining the strengths of Spatial.io and Unity, a personalized virtual space can be developed in a shorter amount of time without compromising the interactive, engaging, and game-based elements that are needed in the virtual space.

Gamification

Gamification elements refer to the usage of badges, rewards, and tokens used in game-based learning as initiatives to influence students' engagement, participation, and motivation in acquiring new knowledge [41] through metaverse platforms like Spatial-Unity. Basic gamification elements like tasks, tokens, and badges can be developed in Unity without any code needed and imported into the Spatial.io platform for further incorporation of aesthetic elements. Gamification features provide students with immediate feedback through rewards and also markers to indicate learning progression, therefore shifting from traditional lessons into dynamic and rewarding experiences as shown by [26] that highlighted gamification enhances students' motivation and supports collaborative and competitive learning environments.

Interactivity and Customization

Interactivity and customization are essential elements that can be used to create a personalized environment. In Spatial.io, users can easily use ready-made templates to create virtual spaces according to specific requirements and manipulate 3D objects to make the space more informative visually [42] Developers can also import objects, videos, images, and audio without any necessary knowledge of coding, therefore making it more appealing to novice users or developers with time constraints such as educators. To add more interactive elements, developers can leverage the toolkit within the Unity platform, which allows interactive elements like tokens or rewards to be developed in this platform and then integrated into Spatial.io. By adding customized interactive elements such as 3D tokens into the learning material, the virtual learning space can be tailored with game-based features, that not only is enjoyable but also suited to meet the needs of the students, therefore potentially enhancing comprehension in understanding abstract concepts in computer science such as data measurement, similar to a recent study that demonstrated how a Geo-Vulcan metaverse learning space simplified the complex issues related to vulcanism [43].

Accessibility and Scalability

The terms accessibility and scalability refer to the extent to which the platform can cater to the user's or developers' diverse needs and abilities and grow and adapt to the increased usage over time without reducing the effectiveness of the platform. As Spatial.io is developed to be used across multiple devices such as tablets, VR headsets, and other mobile devices, therefore the incorporation of Spatial-Unity also leverages the same advantages making it very accessible among users with diverse infrastructures [23][35]. This metaverse platform also does not solely focus on the usage of one operating system, but can be used among macOS and Windows users making it a very compatible platform for a wide range of users. Therefore, more learners will be able to gain educational experiences reduce barriers to entry, and foster inclusivity [22]. Another unique feature of Spatial-Unity is the ability to cater to environments for both small and large groups in a virtual classroom setting making it very scalable and suitable to use. These features promote equitable access to innovative educational tools, ensuring that immersive learning is not limited to well-resourced institutions [35][22].

Potential of Integrating Spatial-Unity in Computer Science Education

The integration of Spatial-Unity within Computer Science holds potential significance for improving the learning experience within this subject. Due to the abstract nature of concepts such as fundamentals of programming, algorithms, data representation, and data measurement, this platform can be the solution to address the issues within this subject to ensure a more effective learning outcome.

Visualization of Abstract Concepts

Similar to other STEM subjects, one of the main challenges accustomed to computer science education, is the challenges due to grasping abstract concepts such as programming, algorithms, computational thinking concepts, unit conversions, resolution, bit depth, and file size calculations. These topics are often presented in a static and theoretical manner, making them seem disconnected from real-world applications and difficult to visualize among students. To address this issue, Spatial-Unity with its immersive features, can help in bridging the gap between this issue by providing interactive 3D visualization that can ease the transitions of grasping abstract concepts. This use of Spatial-Unity is also aligned with the STEM strategies that encourage experiential learning through hands-on activities that may significantly increase comprehension and engagement of abstract concepts such as cybersecurity and data measurement [44]. Integrating the use of Spatial-Unity, could enhance the learning experience of Fundamentals of Computer Science as elements such as simulations, videos, audio, animations, images, and text can be added within this platform and help students understand how theoretical changes affect practical outcomes. For instance, students can visually explore how changes in resolution or bit depth impact image quality, making these relationships clear and memorable.

A study by [45] supports this approach by leveraging the use of metaverse platforms to improve students' understanding of intermediate programming concepts. The study showed that incorporating these platforms, helped students to visualize abstract concepts and provide hands-on simulations. Additionally, the study indicated that allowing students to observe algorithms and data manipulation in real-time and through immediate feedback, improved students' overall comprehension and retention. These findings align with Spatial-Unity's goal of using 3D interactions to transform challenging computer science concepts into accessible, engaging, and memorable learning experiences.

Fostering Deeper Engagement

Engagement refers to the level of interest, participation, and involvement in a particular activity and is often associated with how effectively it influences the learning experience. Therefore, engagement plays a critical role, especially for complex subjects like computer science. Engagement can influence students' motivation and personal growth where it helps in developing problem-solving skills, resilience, and self-efficacy. The use of Spatial-Unity will encourage students to obtain better engagement through immersive experiences that leverage the use of activities that are task-based and related to situations in real life [46].

Among the factors that contribute to engagement are the relevance of the content provided, the supportive environment, the use of the latest technology, and social interactions that can help in creating meaningful discussions. Research by [45]) supports these factors by demonstrating how gamified VR environments significantly increase student motivation and engagement through the incorporation of interactive tutorials that encourage students to learn at their own pace, therefore making the learning process easier, intuitive, and impactful.

Another feature that contributes to students' engagement and promotes self-learning is the use of avatar customization, real-time interactive assessments, and other collaborative STEM activities within the metaverse platform as demonstrated through a study by [47]. Singh applied the use of a Metaverse-Enabled Learning Experience integrated with The Community of Inquiry framework and discovered that students' social, cognitive, and teaching presence enhanced significantly.

By integrating the power of immersive visualization, gamification, and interactive learning, Spatial-Unity is well-positioned to potentially transform the learning of complex computer science concepts into a more effective approach. As stated by evidence from past research, demonstrates its potential to enhance not only

comprehension and retention but also deeper engagement, motivation, and collaboration among students and can represent a significant advancement in how abstract and challenging computer science topics can be effectively learned.

Student Acceptance of Metaverse Platforms

The acceptance of metaverse platforms plays a crucial role in facilitating technology adoption, supporting learning outcomes in the future, and promoting long-term use. It can be measured through different kinds of models such as the Technology Acceptance Model (TAM), Diffusion of Innovation (DOI) Theory, Self-Determination Theory, UTAUT, and UTAUT2. In the UTAUT framework, the acceptance of metaverse platforms among students refers to the extent of willingness to adopt the technology through various influencing factors such as performance expectancy, effort expectancy, hedonic motivation, and social influence that predict the behavioural intentions to use the technology. Previous studies conducted have highlighted critical factors contributing to the adoption of this technology among various subjects such as mathematics, science, sports, and engineering, and performance expectancy, effort expectancy, hedonic motivation, and facilitating conditions arise as significant determinants of behavioural intention to adopt these technologies.

Research conducted in a mathematics classroom setting using metaverse platforms indicated that 89% of the participants achieved grades A and A- after implementing this approach into the learning sessions, hence demonstrating very good performance expectancy. Findings from the research also indicated that students felt motivated while learning using metaverse platforms, proving the increase of hedonic motivation, and this is linked to the use of immersive and interactive features of metaverse platforms [8]. Other studies conducted by [48] and [49] also indicated that facilitating conditions, effort expectancy, performance expectancy, expectancy, and social influence are variables that predict students' behavioural intentions to use and adopt these platforms in their learning experience. Therefore, these variables are identified as significant variables that contribute to the behavioural intention and adoption of metaverse platforms.

Performance Expectancy

Performance expectancy refers to the belief of a person that the technology used will improve their learning outcome and help them achieve specific goals. Previous studies have demonstrated that this is one of the significant variables that predict behavioural intention and adoption of technology [8][49]. Similarly, [50] highlights that performance expectancy significantly influences students' behavioural intentions toward adopting metaverse platforms, demonstrating its critical role in educational technology adoption

Effort Expectancy

Effort expectancy is associated with the level of perceived ease of use of the metaverse platform. It refers to the student's expectation that the technology that they use does not require much mental and physical effort. Metaverse platforms like Spatial.io offer user-friendly navigation that eases the learning process, hence ensuring ease of access and usability, which aligns with both [48] and [51] findings that ease-of-use correlates strongly with behavioural intention.

Hedonic Motivation

Hedonic motivation refers to the enjoyment or pleasure an individual experiences when engaging with technology. Hedonic motivation can potentially be influenced through the interaction of gamification elements that help students to better engage with the technology and create an experiential learning experience, especially for young learners. This factor with studies indicating that students prioritize fun and novelty, particularly when exploring new [52]. [49] further highlight that hedonic motivation strongly influences student engagement in metaverse environments, underscoring the value of creating enjoyable and visually appealing experiences.

Social Influence

Social influence is connected to students' perception of the extent to which important people around them such as teachers and parents influence their belief that the metaverse platform should be used. Social influence is one

of the factors that support the behaviour intention to use this platform as stated in a study conducted by [53] which found that social influence positively influenced students' satisfaction and intention to use the metaverse platform. This finding is also consistent with [49] that teachers' influence significantly impacted students' adoption and engagement towards the acceptance of metaverse platforms. In contrast, a recent study by [54], indicated that Gen Z students in developing countries did not show significant social influence towards the adoption of metaverse platforms. This indicates that though social influence might be a crucial underlying factor contributing to metaverse technology adoption, however, it may vary based on population and context.

Facilitating Conditions

Facilitating conditions refer to necessary resources that are needed to support the use of metaverse platforms such as devices, and support systems that are the key factors that contribute to the successful adoption of metaverse platforms. Reliable technology and equipment such as stable networks and compatible devices play an important role as highlighted by [48] and [49]. Similarly, [55] also supported this statement and emphasized the need for technical support through training that can significantly enhance both attitude and behavioural intentions to use this technology, thus reducing adoption barriers and ensuring sustained use of metaverse technologies.

The integration of UTAUT2 constructs with insights from previous literature underlines the importance of platform design with usability, engagement, and practicality in mind. With its immersive environment, gamification, and focused collaboration, teacher support, Spatial Unity addresses these factors and is thus very appropriate for enhancing secondary students' Fundamental of Computer Science concepts while nurturing motivation for continued use.

The Acceptance of Metaverse Platforms Among Secondary Students

Extensive research has been conducted related to the acceptance of metaverse platforms that primarily focus on higher education, while very few have been conducted on primary and secondary school students. This is a crucial matter as different levels of education may represent a distinct demographic acceptance towards the intention to use metaverse platforms. Among the factors that could potentially influence their acceptance are cognitive development, learning preferences and their familiarity with the technology are determinants that should be considered and can play a vital role in their adoption. Their behavioural intention to use the metaverse, driven by performance expectancy and effort expectancy, is a critical determinant of successful adoption [50][55][53][51].

The cognitive readiness and ability to grasp abstract concepts differ from secondary school students compared to higher education students as shown in previous research related to cognitive framework and readiness measures across these two groups [56]. Metaverse platforms are designed to cater to these developmental differences by offering engaging activities, highly visual representations, and intuitive user-friendly interfaces that are aligned with their level of understanding. The incorporation of immersive gamification elements such as tokens and badges may be an effective solution to attract, motivate, and engage young learners in learning activities compared to university students whose focus is more driven toward career-oriented goals. The influencing factors may prioritize hedonic motivation compared to performance expectancy as secondary school students may focus more on the fun and engaging aspects of this platform. [52][57].

Another important difference that may be found in the accessibility of technology and infrastructure might influence factors such as facilitating conditions toward behavioural intention to use the metaverse platform. In rural areas, limited networks and devices such as headsets might be the contribution, therefore, facilitating conditions, such as school-provided devices and teacher support, play a vital role in bridging these gaps, ensuring equitable access to immersive learning technologies [49][58]. Insights into acceptance can also guide resource allocation, ensuring that investments in metaverse technology are utilized effectively to enhance learning experiences.

However, with the rising interest in immersive learning tools, limited research has focused on the acceptance of these technologies within the population of secondary school students. Previous studies focus on young adults

and students in higher education, thus leaving an apparent gap in how younger students perceive and interact with these immersive platforms. This demographic's unique needs and challenges range from shorter attention spans to greater reliance on teacher guidance underscoring the importance of targeted research in this area. By assessing students' acceptance, educators and policymakers can develop tailored strategies that maximize the benefits of metaverse technology in education [59].

Future studies should identify what modifications may be made to immersive platforms such as Spatial-Unity to best adapt among secondary school students. By addressing and identifying the issues, this platform will offer an immersive, interactive, and collaborative learning experience that caters to the developmental and cognitive needs of younger learners towards factors such as performance expectancy, effort expectancy, and social influence. This proposed research will inform the design of such platforms and support educators in implementing these tools to realize improved learning outcomes and equity in education.

POTENTIAL CHALLENGES & CURRENT SOLUTIONS

Like other introductions to new technologies, the acceptance of metaverse platforms including Spatial-Unity may encounter barriers and these challenges must be identified and addressed to ensure that its integrations can become a success. Among the prominent hurdles that might be an issue is the reliability of network speed and coverage in secondary schools, especially in rural areas. According to the reports from the Digital Education Policy (DEP) in Malaysia, these issues are acknowledged and measures to overcome this challenge have been taken action through initiatives such as the **JENDELA project**, in collaboration with the Ministry of Communications and Digital, which aim to install Points of Presence (PoPs) in schools to improve broadband access within a 2.5-3 km radius, particularly benefiting underserved areas [60].

Another challenge that might be faced in the adoption of metaverse platforms is due to financial constraints in schools whereas to fully integrate this technology seamlessly, the infrastructure and technological devices must be catered to support the features within metaverse platforms. To overcome this challenge, the Ministry of Education has taken strategic steps by building partnerships with NGOs and private sectors to ensure that digital devices and other resources are distributed to schools, and underserved areas [60].

Educators play a crucial role in the adoption of metaverse platforms. Resistance from educators may pose a threat to the successful integration of platforms such as Spatial-Unity. The statistics on educator's proficiency levels in digital literacy indicated that only 2% of the educators in Malaysia have reached advanced digital skills and this might pose a threat [60]. The resistance among educators might be due to the unfamiliarity of the technology or insufficient training, resulting in unwillingness to implement this technology in the educational setting. To overcome this challenge, the Ministry of Education has taken the initiative by introducing metaverse platforms such as Spatial.io in 2023 under a project called MetaSkool coordinated by the Malaysian Digital Economy Corporation (MDEC) and The National University of Malaysia [61]. Metaverse technology was introduced to nine pioneer schools chosen in Malaysia to educate teachers and students about this new technology. However, the implementation of this technology is still in the early stages, and the acceptance among students remains uncertain, particularly across different states, subjects, and age groups.

Though anticipated challenges may arise such as infrastructure and technological issues, resistance from educators, and financial issues, the ministry has taken strategic actions to help overcome the barriers that may arise to provide a better transition of metaverse technologies within the educational setting. By addressing current obstacles, the acceptance of metaverse such as Spatial-Unity can be fully embraced, adopted, and utilized by secondary school students.

CONCLUSION

The implementation of the combination of virtual reality and augmented reality through metaverse technologies holds significant value in providing a better learning experience through the use of interactive and immersive elements integrated into diverse subjects. Metaverse technologies have progressed among various platforms including 2-dimensional spaces such as Gather Town to 3-dimensional spaces such as Zepeto and Spatial.io, each with customized benefits to improve learning outcomes of both STEM and non-STEM subjects. Metaverse

platforms can help transform abstract concepts into forms of visuals that make it more tangible. Therefore, introducing the latest metaverse technologies is crucial to ensure that the latest technologies are fully used and integrated to provide a better learning experience and outcome. This concept paper informs the potential of leveraging the use of Spatial-Unity in STEM subjects, particularly within the Fundamental of Computer Science subjects, focusing on secondary school students. Though acceptance of this technology has been extensively studied in higher education, the acceptance of secondary school students remains underexplored, and there is a need to further explore its potential to provide innovations that are effectively designed, equitably implemented, and capable of delivering meaningful educational outcomes.

IMPLICATIONS & FUTURE RECOMMENDATIONS

Through the exploration of past empirical research, the researcher identified the current gap that remains underexplored and the need to explore the acceptance of Spatial-Unity metaverse platform for learning Fundamentals of Computer Science concepts among secondary school students. This section will explain the implications and future recommendations for future research.

The use of Spatial.io and Unity has been shown to provide an immersive learning experience and the integration of both Spatial-Unity metaverse platforms can potentially provide a better metaverse space in terms of interactivity and immersive characteristics. Implementing the use of gamification elements that can be assembled in a shorter amount of time, can potentially aid in enhancing motivation, comprehension, and engagement among students particularly for learning abstract or complex concepts within the Fundamental of Computer Science subject. Previous studies have demonstrated the ability to enhance communication, collaboration, and reflective learning through the use of metaverse technologies [8][62][63], therefore indicating high potential in transforming conventional approaches to a more immersive learning experience [64]. This finding is significant as it highlights the need to explore how secondary school students interact with and accept such technologies as the level of acceptance can differ based on different group ages, subjects, and type of technology implemented.

The current metaverse platforms range from virtual spaces that are easy to develop to more complex virtual spaces that need advanced digital proficiency. It also offers basic features to more advanced features that can support elements such as gamification. Through this concept paper, educators can be informed of the most suitable metaverse platform to implement and the potential of Spatial-Unity as it not only can provide elements that are easy to develop, but also provide advanced features that are needed to make the learning experience better. Additionally, through understanding the benefits and current challenges, educators can equip the necessary skills and devices needed to make the transition of integrating this tool into the classroom effectively.

As the educational environment evolves, the integration of the latest technologies is a necessity and therefore it is imperative to invest in upgrading infrastructure, training programs, and curriculums to support and promote the acceptance and adoption of these technologies among students primarily. Therefore, from this concept paper, policymakers can be informed of current initiatives that have been taken and further steps to take to ensure that students leverage most of the benefits that these metaverse technology has to offer.

Therefore, future research should focus on the exploration of Spatial-Unity metaverse platforms for learning Fundamental Computer Science concepts among secondary school students. Though acceptance has been studied in higher education settings as demonstrated [65] and pre-university level students [66] acceptance among secondary school students remains underexplored, especially within Malaysia’s educational setting. Studies on the usage of metaverse platforms have also been explored within STEM subjects such as science, mathematics, and language [67] however the usage of it has yet to be rigorously studied within the computer science subjects. Therefore, this research will provide insight of understanding the younger learners' needs and preferences for implementing Spatial-Unity into their learning experience. The guidance of established theories such as UTAUT will guide and inform all stakeholders of how factors such as performance expectancy, effort expectancy, hedonic motivation, and behavioural intentions will influence the use of this technology and how Spatial-Unity can aid in supporting the understanding of abstract concepts within the Fundamental of Computer Science Curriculum. Addressing these gaps can improve the quality of education and the potential benefits of the latest technologies.

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