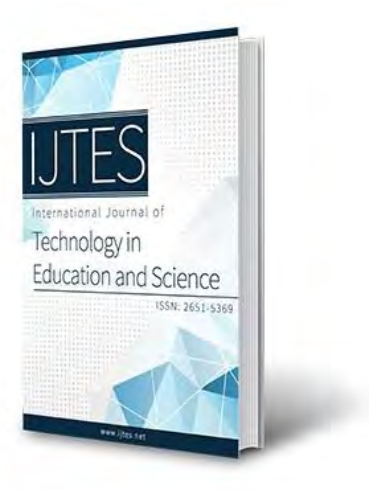

www.ijtes.net

Exploring Mixed Reality Board Games as an Innovative Educational Tool for Teaching History in Primary Schools

Priyan L. Jayamaha
Yoobee College of Creative Innovation, New Zealand

To cite this article:

Jayamaha, P.L. (2024). Exploring mixed reality board games as an innovative educational tool for teaching history in primary schools. *International Journal of Technology in Education and Science (IJTES), 8*(1), 20-40. https://doi.org/10.46328/ijtes.519

IJTES International Journal of Technology in Education and Science
2024, Vol. 8, No. 1, 20-40 https://doi.org/10.46328/ijtes.519

Exploring Mixed Reality Board Games as an Innovative Educational Tool for Teaching History in Primary Schools

Priyan L. Jayamaha

Article Info

Article History

Received:
17 July 2023
Accepted:
14 November 2023

Keywords

Educational apps
Educational board game
Mixed Reality
Augmented Reality
Extended Reality

Abstract

This study investigates the challenges of teaching history to primary school students and the endeavour to develop a board game, supported by educational apps and augmented reality, to enhance the learning experience. The initiative is in response to the New Zealand Ministry of Education's mandate that New Zealand's history must be taught in all Kura and schools' local curriculum from 2023. (Ministry of Education, 2023). The study was conducted in two phases. The first phase explored teachers' attitudes towards using technology as a teaching aid and the availability of digital devices for interactive teaching and learning. The results showed that many teachers are supportive of using board games and technology in their teaching. In the second phase, a board game was developed and trialled with a group of teachers and students as expert representatives for the target group. The results showed that the mixed reality board game has great potential and is well worth continued development. The study also suggests that emerging disruptive technologies such as mixed reality can create effective and engaging learning and teaching environments.

Introduction

To ensure that learners have a comprehensive understanding of New Zealand's past and how it has and how they have shaped the country, Te Takanga o Te Wā and Aotearoa New Zealand's histories will be integrated into all kura and schools' marau ā-kura and local curricula, starting in 2023. The aim is to equip learners with the necessary knowledge to appreciate the fundamental aspects of New Zealand's histories and their impact on the nation. (Ministry of Education, 2023).

Introducing New Zealand history to primary school children provides a foundation for understanding how the past has shaped our present and future. By exploring the culture, values, knowledge, beliefs, worldviews, and experiences of their ancestors, children can form opinions and gain a sense of their identity. This approach also addresses the issue of inconsistent delivery of New Zealand history across all school levels and fills gaps in knowledge that may have existed in the past. (The official website of the New Zealand Government, 2019)

While learning history is crucial to a child's education, teaching it at the primary school level presents challenges. Preliminary research has revealed that some teachers feel the curriculum places greater emphasis on literacy,

numeracy, and other subjects, rather than New Zealand history. Factors contributing to this perspective include a lack of preparation time, teachers' limited knowledge of New Zealand history, and the difficulty of engaging students in the subject.

Teaching history in a traditional manner that relies on a chronological presentation of events can be challenging for primary school students. This is because it may require them to engage in passive learning by simply memorizing information. To address this issue, Te Takanga o te Wā - Māori History Guidelines (Ministry of Education, 2015) recommend alternative pedagogical approaches that encourage more active engagement with the subject matter. These approaches include using storytelling, artefacts, expert input, images, and current events to help students make meaningful connections to historical events.

In addition to these recommended teaching methods, the use of board games and emerging technologies such as mixed reality can further enhance the learning experience for students by providing a more immersive and engaging approach that encourages collaboration, interactivity, storytelling, and empathy. However, there is currently limited understanding of the benefits of mixed reality in learning history. This study contributes to this knowledge gap by identifying the effectiveness of pedagogies that integrate technologies such as mixed reality, educational apps, and board games in facilitating enjoyable and engaging history lessons for students.

Definitions

Augmented Reality (AR)

AR technology is used in games, apps and in many industries to present information to the viewer by overlaying digital content over the real world by using a smart device such as a smartphone or a tablet. (FINK, J., 2017, p 9)

Virtual Reality (VR):

VR technology is used in games, apps and used in many industries to experience digitally constructed worlds and immersion. VR requires a special device such as HTC Vive and Oculus Rift. You can also use a low-cost Google Cardboard with limited functionality that can be good solutions for students. (FINK, J., 2017, p 9)

Mixed Reality (MR):

Mixed Reality (MR) is a blend of physical and digital worlds, unlocking natural and intuitive 3D human, computer, and environmental interactions. This is often done by combining AR, VR with the real-world setting. (Qianw, 2023)

Can AR, VR and Board Games Support Active Learning?

Technology has become an integral part of our daily lives, fundamentally transforming our interactions, work, learning, and content consumption (Graham, L., 2019). The advent of the internet, smart devices, apps, and games

has had a profound impact on education, revolutionising the way we learn and teach. We now have access to numerous educational apps and games that enhance student learning, informative videos that demonstrate practical skills, online learning platforms that enable remote education and knowledge sharing.

Virtual Reality (VR) and Augmented Reality (AR) are gaining popularity due to their unique ability to present information and tell stories through interactivity and immersion. A study conducted by Utami et al. (2019), titled *Effectivity of Augmented Reality as Media for History Learning*, highlights how AR is being utilized by students to learn about the historical subjects of Malang in Indonesia. The research emphasizes the limitations students face in physically visiting temples, and how AR technology provides an opportunity for them to interact with 3D models of the sites, enabling a more engaging and interactive learning experience (Utami et al., 2019).

Furthermore, AR and VR technologies serve as powerful tools for storytelling, fostering empathy, motivation, and enjoyment. Storyteller Gabo Arora leverages VR technology to raise awareness about social issues, aiming not only to deepen understanding but also to evoke empathy for those experiencing these challenges (Ullman, E., 2017). By employing VR storytelling, Arora's mission is to create a genuine connection with the struggles faced by individuals in various circumstances.

According to the NMC/CoSN Horizon Report, K-12 Edition, middle school teachers are implementing virtual reality (VR) devices to enable students to experience expeditions such as Apollo 11 and underwater simulations, offering immersive encounters with environments that would otherwise be impractical to visit. While VR allows users to immerse themselves in digitally created artificial environments, augmented reality (AR) can enhance real-world settings by overlaying information and data. (Freeman et al., 2017)

In a study conducted by Karen Schrier (2006), the use of AR games to teach 21st-century skills was explored. The experiment took place at the historic Battle of Lexington site during the American Revolution. Participants engaged in a game where they "relived" the events of April 19, 1775, and were tasked with determining who they believed fired the first shot—an enduring mystery to this day (Schrier, 2006). Using GPS-triggered virtual historical figures and items on their PDAs, participants interacted with the augmented reality elements. The study demonstrated positive results in terms of learning 21st-century skills through AR games, which provided an authentic learning environment that was motivating, enjoyable, and engaging. Furthermore, AR games showed potential in making vast amounts of information more navigable, intriguing, and memorable (Schrier, 2006).

Despite the significant interest in using AR/VR technology in education, there are several reasons why it is not commonly implemented in classrooms. One primary challenge is the limited availability of content suitable for educational purposes. According to the Freeman et al. (2017), it will take a few years for VR to become an integral part of schools worldwide (p. 46). Moreover, a survey conducted by "Extreme Networks" among educational institutions revealed that although over half of the respondents expressed interest in VR, only a quarter currently utilize it in the classroom, with a mere 3% teaching students to create VR content (Freeman et al., 2017, p. 46). Another obstacle is the limitation of AR and VR is its tendency to be primarily focused on individual experiences, often restricted to independent use due to the requirement for specialized gear. Collaborative play and group

interactions may be hindered by the need for each participant to have their own VR setup, which can be costly and impractical for many educational institutions.

On the contrary, board games require active participation and foster collaboration, thereby promoting social interaction, sharing, teamwork, problem-solving, and discussions. According to a study conducted by Laurea University of Applied Sciences demonstrated the potential of board games in enhancing children's social learning and emotional skills. A board game creates a dynamic setting for peer-based learning, as children engage wholeheartedly in gameplay. The study applied Verba's threefold framework - activity, sharing, and management and the findings underscored children's enthusiastic participation and adherence to game rules throughout sessions. This peer-group learning contrasts with competitive games, shedding light on the undervalued significance of fostering social interaction and collaborative learning over individual triumph. (Marjanen, P., 2011).

During the initial phase of my research, I consulted several primary school teachers who utilise board games as a teaching tool in their classrooms. These teachers firmly believe that board games effectively support their students' critical thinking, inquiry, reasoning, collaboration, problem-solving abilities, while also making the learning experience enjoyable (see Figure 2). Moreover, many teachers employ board games to enhance students' literacy and numeracy skills.

By merging the physical and collaborative aspects of board games with the immersive and digital nature of augmented reality (AR) and virtual reality (VR), physical learning can elevate the user experience and boost engagement by incorporating multiple layers of real-world and digital interactivity. In the first two editions of JSET's special theme on games and immersive participatory simulations, Squire and Jan (2007) define AR as: "...games played in the real world with the aid of digital devices (such as PDAs and cellphones) that overlay a fictional layer onto the real-world context." This integration allows students to physically engage in a game with their peers while still receiving relevant information through AR and VR technology. Consequently, these approaches can create enjoyable and captivating experiences while delivering a greater amount of memorable and meaningful information.

A historical board game offers students a unique opportunity to delve into and experience a specific time period as if they were interacting with the real world. While immersing themselves in this historical world through the game, they simultaneously acquire relevant historical knowledge pertaining to the subject matter.

Moreover, the board game facilitates collaborative play, enabling students to learn and share knowledge with their peers. Augmented reality (AR) and virtual reality (VR) technologies further enhance the learning experience by providing an additional layer of information to the learners, fostering increased interaction, enjoyment, and immersion. Additionally, incorporating challenges, quests, and achievements within the game can create motivation for students to further engage and participate.

By integrating board games with AR and VR, an active learning environment filled with excitement and

enjoyment can be established. Students can actively participate, explore, and learn while being captivated by the engaging and interactive elements of the game.

Method

Phase 1 - Preliminary Research

During the initial phase of the project, interviews and surveys were used to gather valuable insights from primary school teachers across various schools. A combination of interviews and surveys served as the primary methods of data collection, providing essential information on: Attitudes and opinions of teachers regarding the integration of technology in classroom teaching; Current utilisation of technology in the teaching and learning processes; Accessibility and availability of digital devices for both students and teachers to facilitate effective teaching and learning; and proficiency levels of both teachers and students in utilising technology.

The research involved conducting a total of 10 interviews and obtaining responses from 21 participants through an online survey. All participants were primary school teachers who taught at different levels within primary schools in New Zealand. This diverse sample aimed to capture a range of perspectives and experiences related to the use of technology in the classroom setting.

It is important to acknowledge that the survey was conducted online, which may have attracted responses primarily from teachers who are actively engaged with the internet and digital resources. Therefore, it is necessary to exercise caution when generalising the findings to the entire country's teaching population. However, within the scope of this study, the obtained results were deemed sufficient to provide valuable insights for the subsequent stages of the research.

The COVID-19 pandemic significantly impacted this phase of the research. Due to restrictions and limitations on in-person interactions, some of the interviews were conducted through online video conferencing. Furthermore, during the pandemic, teachers and schools were faced with the challenges of transitioning to remote learning and had limited time and resources to allocate for research participation. Consequently, the response rate for the survey was lower than anticipated.

Despite these limitations, the data collected in this phase contributes to our understanding of teachers' perspectives on technology integration in the classroom, considering the unique circumstances imposed by the pandemic.

Phase 2 - Development and testing the Mixed Reality Boardgame Prototype

The preliminary findings from Phase 1 of the research served as the foundation for Phase 2, where the focus shifted towards developing a board game that integrates mixed reality technologies. This game was specifically designed to facilitate the learning of early Polynesian migration among primary school students in New Zealand.

Throughout the development process, a dedicated website was created to share updates and progress with teachers

and other interested parties. This platform also served to gather valuable feedback from the stakeholders involved.

Following the development of the prototype, a small group of primary school teachers participated in testing the board game. Additionally, the game was tested and implemented in two primary schools, involving multiple groups of students from Year Five and Six.

By involving both teachers and students in the testing process, valuable insights were gathered regarding the game's engagement, educational value, and overall usability. The feedback obtained from these tests helped to refine and improve the board game, ensuring that it effectively catered to the specific needs and learning abilities of students. This testing phase also aimed to identify any limitations or challenges encountered during the project, providing valuable insights for future developments and improvements.

It is worth mentioning that Project Phase 2 also faced COVID-19 disruptions, including lockdowns and social distancing, which hindered group play and physical contact required for testing. Consequently, play testing was more challenging and time-consuming than initially expected.

Phase 1 - Preliminary Research findings

Interviews

The interview encompasses 10 primary teachers from multiple schools, spanning various grade levels within the primary education system.

Teaching New Zealand History in the Classroom

In New Zealand classrooms, a diverse range of approaches is employed to teach history, each with varying degrees of emphasis. Among these approaches, the Treaty of Waitangi holds significant importance, with educators introducing the concept to students from their early primary years and delving into more profound discussions as they progress through the educational system. While one teacher may choose to integrate history studies with te reo Māori language, another may incorporate music and waiata (traditional Māori songs) into their lessons. These approaches highlight the existence of multiple levels of engagement within the classroom, incorporating diverse historical content and employing different teaching methods and practices to captivate students' interest in the subject.

Cultural Diversity in the Classroom

Cultural diversity within the classroom undoubtedly plays a role in shaping students' engagement with and the teaching of history. Teachers' perspectives on this matter can vary, with some asserting that a higher level of cultural diversity fosters greater interest in learning New Zealand history, while others contend that students from different cultural backgrounds may struggle to connect with the subject matter. Notably, those students who are direct descendants of early settlers in New Zealand often exhibit heightened engagement when learning about

their own ancestry, culture, and heritage.

However, it is important to note that conclusive data regarding the strong relationship between students' cultural diversity and their engagement in New Zealand history is limited. While anecdotal evidence and observations suggest potential correlations, further research is needed to establish firm conclusions. Nonetheless, it is evident that teachers adapt their teaching approaches to suit their students' interests and backgrounds, allowing for more personalized and engaging history lessons.

Game Based Activities in the Classroom

A significant number of teachers have embraced the use of games to support students' learning, particularly in literacy and numeracy studies. These educators believe that board games foster a collaborative and cooperative learning environment, encouraging students to share knowledge with their peers. Board games, as well as digital games, have proven to be valuable tools for teaching and engaging students, particularly at the primary school level. Students could play games both with their teacher and independently, allowing for interactive and independent learning experiences.

Use of Technology in the Classroom

In today's classrooms, most teachers utilise some form of digital technology to enhance their teaching. However, the extent of technology integration varies based on the preferences of individual teachers, their level of technological proficiency, and the availability of technology resources. Teachers employ a range of digital tools, such as YouTube videos, internet resources, online games, and educational apps, to support student learning.

Additionally, resources like Google Cardboard, Minecraft Education Edition, and Google Expeditions are used to facilitate interactive learning experiences. While teachers value the benefits of digital technology, they also emphasize the importance of maintaining a balance between technology usage and social interactions.

During my interviews, it became evident that teachers possess a strong level of technological proficiency, enabling them to effectively incorporate digital devices and equipment into their teaching practices. Most teachers and students have access to digital devices like iPads and Chromebooks. However, it is worth noting that in some classrooms, the availability of digital devices may be limited, with students having to share a single device among several individuals.

The consensus among the teachers is that technology greatly enhances student engagement and is an essential aspect of primary school education. Teachers encourage students to be creative in their use of technology, empowering them to go beyond being passive consumers. However, one drawback is the potential disruption caused by technological failures during classroom sessions.

Therefore, it is important for technology to be user-friendly and easily operated by teachers without requiring

extensive technical knowledge. Overall, the use of technology in the classroom is viewed positively by teachers, who acknowledge the numerous benefits it brings to the teaching and learning process.

Online Survey

The survey collected data pertaining to the range of historical topics addressed across different classes, the implementation and effectiveness of game-based activities, the utilization of digital technology in teaching, and the overall level of technological proficiency among both teachers and students.

Table 1. School Years of Teachers Participated

	Year 1-2	Year 3-4	Year 5-6	Mixed years
Number of Teachers	3	4	5	9

The online survey encompasses 21 primary teachers from multiple schools, spanning various grade levels within the primary education system as shown in table 1.

Table 2. Teaching of New Zealand History

Teach New Zealand History	Do not teach New Zealand History
15	6

Out of 21 teachers participated in the survey 15 teachers taught New Zealand History while 6 teachers did not.

Table 3. Board Game Activities to Facilitate Teaching

Use board games	Do not use board games
15	6

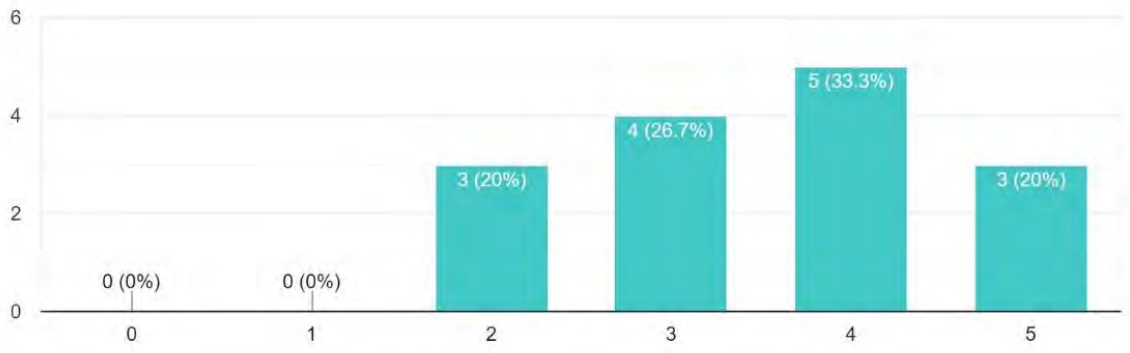

Figure 1. Effectiveness of Using Board Games

0 - Not effective at all 5 - Extremely effective

Out of 21 teachers 15 use board games for teaching and 11 teachers rated the learning effectiveness as 3-5, from a 0-5 scale. (see Figure 1) They also thought that board games support collaboration, communication, critical

thinking, strategic thinking, literacy and numeracy, engagement, problem solving and fun and enjoyment (see Figure 2).

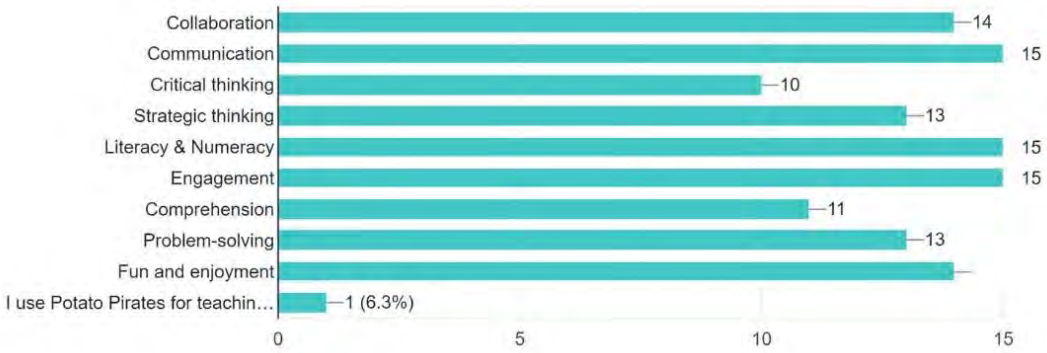

Figure 2. Skill Development through Board Games

The survey also indicates the use of technology in the classroom and 19 teachers use chrome books and 14 use Apps and games and 13 use videos and smart devices and in contrast, 2 use AR/VR (see Figure 3). They also agreed that using digital technology is an effective method for teaching students (see Figure 4).

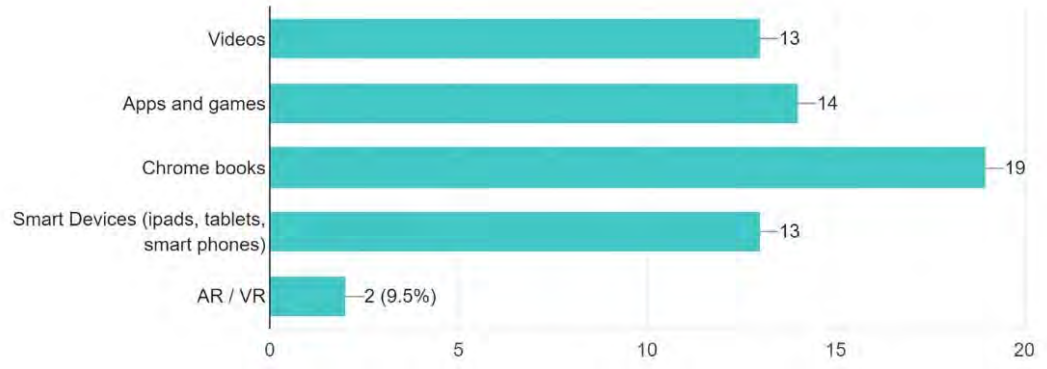

Figure 3. Use of Digital Technology in Teaching

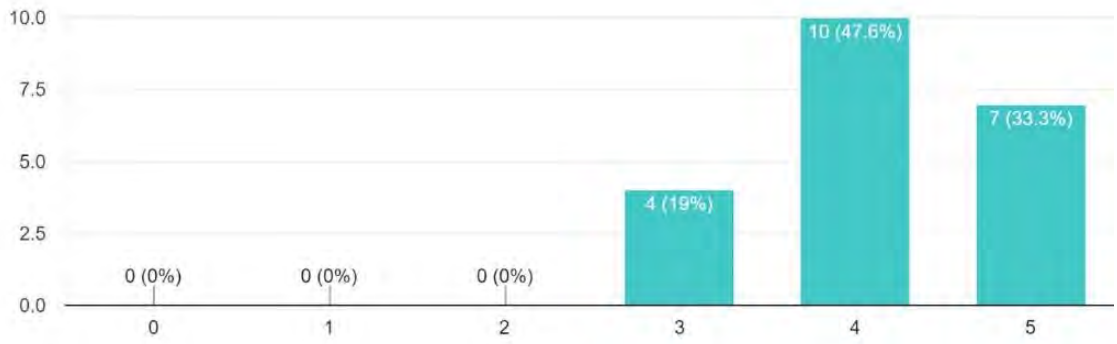

Figure 4. Effectiveness of Using Digital Technology

0 - Not effective at all 5 - Extremely effective

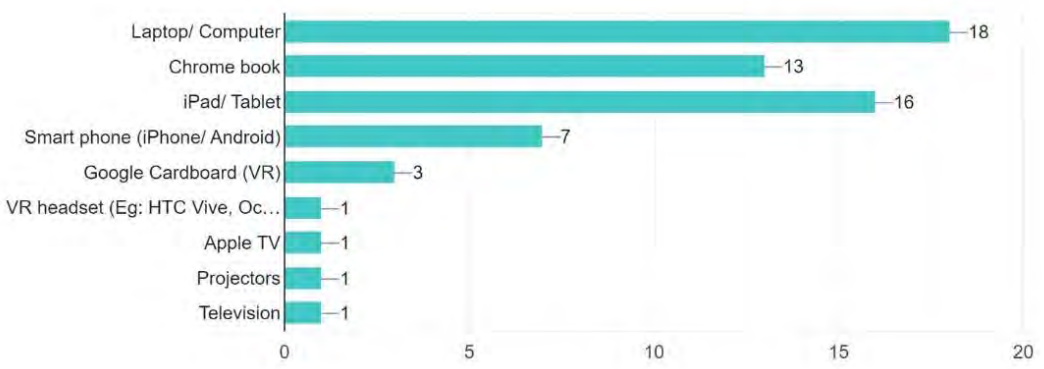

Figure 5. Digital Devices Available for Teachers to Support Teaching

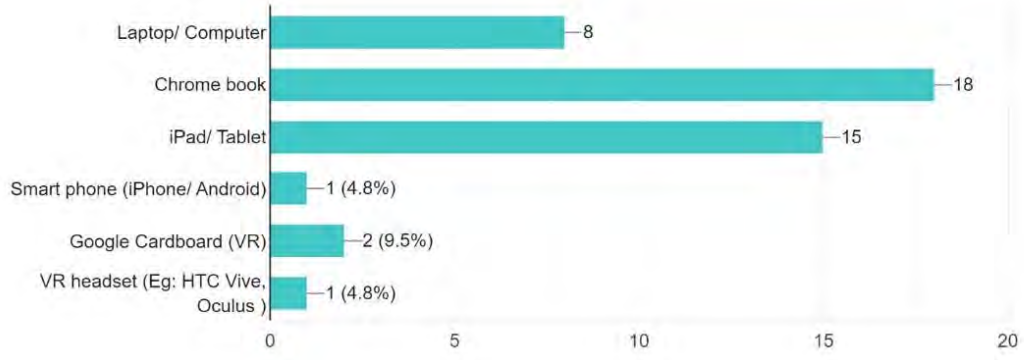

Figure 6. Digital Devices Available for Students

Most of the teachers had access to resource such as laptops/computers and iPads/ Tablets, while most students had access to Chrome books and iPads/Tablets. Only small number of student and teachers had access to VR devices.

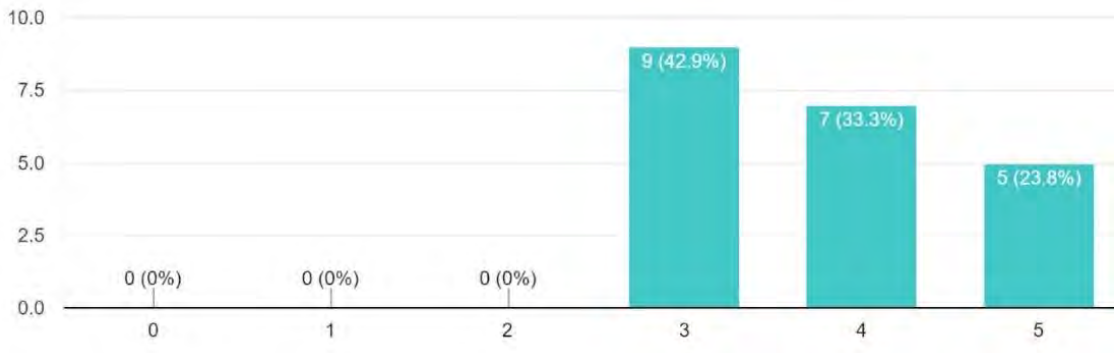

Figure 6. Digital Proficiency of Teachers

0 - Poor 5 – Excellent

All teachers rated their digital proficiency at between 3-5 which indicates that they are confident in using digital devices (see Figure 6). Teachers also rated their student's digital proficiency from their understanding. While most teachers rated their student's digital proficiency as confident, a small number of teachers rated their student's

digital proficiency low (see Figure 7). Survey also indicated that most of the teachers had above-average knowledge of AR and VR technology.

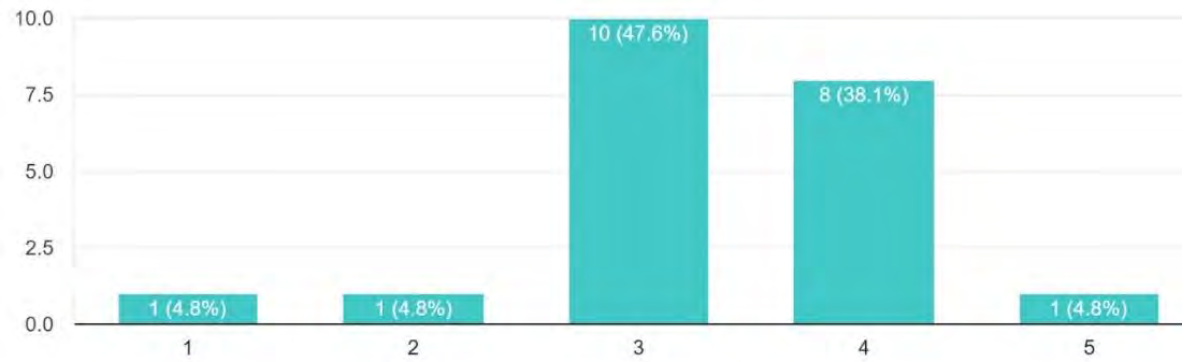

Figure 7. Digital Proficiency of Students

0 - Poor 5 - Excellent

Preliminary Research Summary

Upon examining the interview themes and online survey results, it becomes evident that the themes closely align with the survey findings. A notable variation exists in the way New Zealand History is taught in classrooms, particularly regarding subject content. A prevalent and beneficial approach employed by most teachers involves the use of board games as an effective tool to foster collaboration, communication, literacy, numeracy, engagement, and other essential skills.

Furthermore, the majority of teachers demonstrate commendable digital literacy and an enthusiastic willingness to incorporate various digital technologies and tools into their teaching practices. A substantial number of participating teachers confirmed that their students have access to Chromebooks and iPads, highlighting the availability of these devices in the classroom.

It is noteworthy that 18 teachers possess some knowledge of augmented reality/virtual reality (AR/VR) and have reported positive experiences with this technology in their instructional approach. However, it is essential to acknowledge that the accessibility of VR technology and devices for both teachers and students remains limited.

In summary, the results strongly emphasize the prevailing positive attitude of teachers towards integrating technology in the classroom for instructional purposes. The widespread usage of digital technology in the learning environment is evident, with both teachers and students having access to digital devices. Additionally, the teachers' commendable proficiency in utilizing technology showcases their confidence in leveraging digital tools to enhance their teaching practices.

The Phase-1 research findings and invaluable teacher feedback significantly informed the Phase-2 development process. This feedback played a crucial role in crafting the board game and strategically selecting appropriate technology to ensure a practical, enjoyable, and highly beneficial gaming experience for both teachers and

students.

Phase 2 - Development of the Mixed Reality Board Game

Methodology

History of Early Polynesian Migration

During phase 2 of the project, various investigations and explorations carried out to understand the history of early Polynesian migration to New Zealand. A variety of texts and resources were analysed to obtain a holistic view of the subject and to provide historically and culturally appropriate information on the topic.

Table 4. Resources Used

Source	Type	Information
Auckland War Memorial Museum	Museum	Polynesian waka, tools, culture, Migration
Te Toki Waka Hourua	Organisation	https://www.tetoki.org/
Te Papapa Museum Website	Museum Website	Waka models, tools, culture, Stars
We, the Navigators	Book	Traditional navigation, Voyaging Canoes, Wayfinding, Star navigation
Polynesian Navigation and the Discovery of New Zealand	Book	Discovery and Settlement of the Pacific, Traditional navigation, Voyaging Canoes, Wayfinding, Star navigation
Tangata Whenua: An Illustrated History	Book	Māori history from ancient origins through to the twenty-first century
Teara -The Encyclopaedia of New Zealand	Website	Traditional navigation, Voyaging Canoes, Migration, Wayfinding, Star navigation, Food, waka traditions.
Science Learning Hub	Website	Māori compass, Voyaging Canoes
Te Ao Hou	Website	Traditional Food
University of Hawaii	Website	Traditional Pacific Island Crops
Victoria University of Wellignton	Website	The use of stars in Navigation
Papa Mau: The Wayfinder	Film	The journey of an iconic voyaging canoe Hōkūle‘a under the guidance of Papa Mau
Hokulea - Polyneisan Navigation Society	Website	Polynesian voyaging techniques and the traditional art of non-instrument wayfinding.

New Zealand History Curriculum

The New Zealand Social Science Curriculum (Ministry of Education, n.d.) and the Māori History Guidelines by the Ministry of Education (Ministry of Education, 2015, p.5) were carefully examined to uncover insights into early migration and voyaging topics.

According to the Māori History Guidelines, teachers are encouraged to establish connections with the first people of Aotearoa New Zealand and explore the reasons and desires behind voyaging and discovering. Students are prompted to delve into how people learned about these activities, their way of life, and the emotions associated with leaving home to explore new territories. The exploration also involves understanding what Aotearoa New Zealand was like upon their arrival and the adaptations required to thrive in the new environment. Furthermore, the curriculum encourages the investigation of the means of travel and ocean navigation techniques, along with the technology employed during that period (Ministry of Education, 2015). However, it is important to note that the information on this subject remains limited at the time of this research due to the ongoing restructure of the New Zealand History Curriculum. As a result, comprehensive resources will only be available to schools in the year 2022.

Boardgame Design

Throughout the development of the board game design, a wide range of game concepts and gameplay mechanics were thoroughly explored. The primary goal was to craft an engaging, educational, and practical board game that can be easily played within a classroom setting, avoiding overly complex gameplay.

An exploration game was developed featuring cooperative game mechanics that promote teamwork to simulate real-world sailing experiences. Instead of fostering competition within the team, the game emphasizes the significance of unity, encouraging players to collaborate closely to overcome the challenges of voyaging together.

The game was played on a board (see figure 8) where each player takes a turn to roll the dice to move the waka hourua (double hull canoe) on the ocean grid. They encounter a myriad of events and challenges triggered by event cards (refer to Figure 9. For example; storms, broken sail, wind in a certain direction will have an immediate impact on the voyage.

Figure 8. Game Board

Figure 9. Event Cards

During the voyage players are also responsible for maintaining their well-being, waka and knowledge points. This aspect of the game underscores the significance of maintaining both mental and physical health, fostering personal skills, knowledge, and contributions to the team's success, while also prioritizing the safety and upkeep of the waka and its crew. The game thus highlights the holistic approach required for a successful and fulfilling voyage. With the inclusion of Character cards (see figure 10), players can assume specific roles during the voyage, such as Navigator, Builder, Hunter, Healer and Crew member. These cards enable players to engage in immersive roleplay, connecting with the diverse skills, roles, and responsibilities of historical times. By embodying these characters, players gain a deeper understanding of the challenges and intricacies faced by different individuals during the voyage, making the gameplay experience both educational and enriching.

Figure 10. Character Cards

Integration of Augmented Reality and Virtual Reality Technology

The integration of VR technology in the board game was initially explored. However, during phase1 research, it was discovered that the accessibility of VR head mounts and devices for both teachers and students was limited. To address this issue, a low-cost VR solution, Google Cardboard (*Google Cardboard – Google VR*, n.d.), which can be used with a smartphone to create a more affordable VR experience, was considered. However, it was realized that the Google Cardboard also requires a smartphone with specific technical specifications, posing a potential problem for teachers and students.

Due to the potential technical limitations and challenges associated with accessing compatible smartphones, the decision was made not to integrate VR into the board game. Instead, the VR experience underwent transformation into 360 experiences, granting participants the ability to explore, observe, and interact within a 360-degree digital environment.

The "Waka 360" experience was crafted to enable participants to observe and interact with a Waka Hourua, a double-hulled canoe of historical importance. (See figure 11) As users navigate around the virtual waka, they are provided with insights, including information about distinct components and the materials adroit craftsmen employed.

Similarly, the "Star 360" feature was developed to offer users the opportunity to observe and interact with night sky. (See figure 11) Given the historical significance of star navigation in early Polynesian seafaring, this element serves as a crucial educational aspect. Users engaging with this module will encounter insights about assorted stars, and their significance in the context of navigation.

Figure 11. Waka 360 (left) and Star 360 (right)

Augmented reality emerged as an ideal technology for enhancing the board game, owing to its inherent simplicity and user-friendly nature. Utilising AR merely demanded a smartphone, tablet, or iPad, making the experience effortlessly accessible. Moreover, AR offered an extensive array of media options, encompassing animation, 3D models, images, text, video, and sound, thereby diversifying the modes through which information could be

conveyed. Notably, preliminary Phase 1 research underscored the widespread prevalence of iPads and tablets among both students and teachers, as depicted in Figures 5 and 6.

In the board game's implementation, AR Cards (see Figure 12) were employed as a medium to deliver questions and corresponding answers to the player. Through the utilisation of a device's camera, the app employed image recognition technology to identify the AR Card as an image target. This seamless recognition process facilitated the loading of pertinent information linked to the specific card. (See figure 12) As the user continued to keep the AR Card within view, the app adeptly tracked the displayed information, ensuring a coherent and synchronized experience.

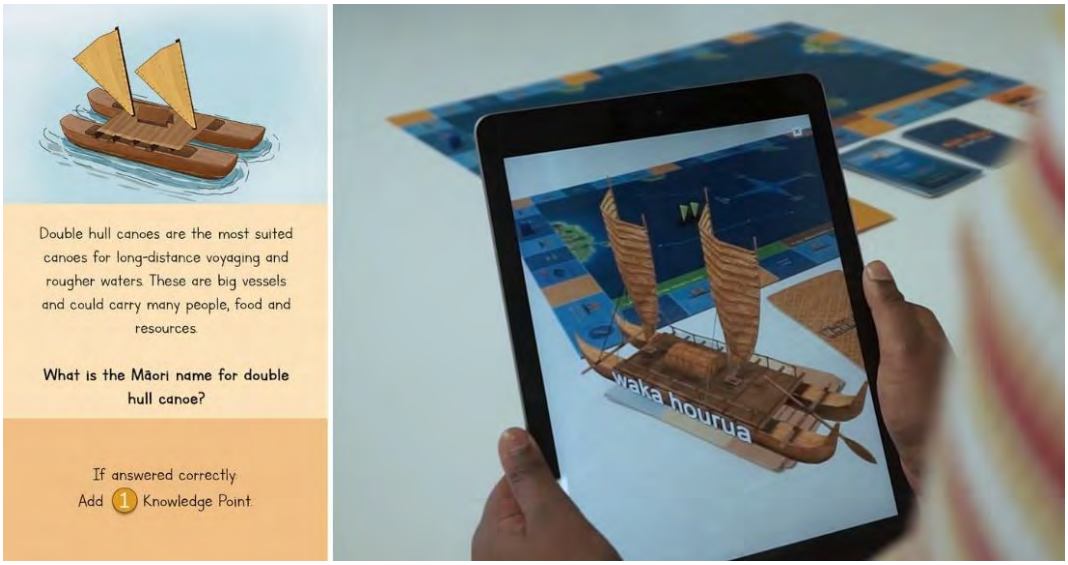

Figure 11. AR Card (left) and AR Experience (right)

Figure 12. Waka Hourua App

To enhance interactivity and enrich the AR experience, a range of functionalities were incorporated. These contributed to an immersive and engaging user experience, allowing for greater interaction and the provision of expanded information. For example, elements such as Māori words and audio clips were incorporated fostering an educational grasp of te reo Māori and enriching the learning experience through auditory engagement.

The 360-degree experiences and the augmented reality features were developed using Unity Game Engine. These components were seamlessly integrated within a singular application, designed for compatibility with a range of smart devices (see Figure 12). This app functions in conjunction with the physical board game, delivering a comprehensive and engaging user experience. Its availability extends to both the Apple Store and Google Play Store, ensuring effortless accessibility through downloadable installation.

Results

Game Trial

The game's progression occurred across two distinct settings and timeframes; a necessity driven by the prevailing COVID restrictions. Initially, a trial was conducted involving a limited number of primary school teachers. Subsequently, the game was facilitated by teachers to groups of students within a primary school classroom environment.

Following the gameplay sessions, a feedback collection process was undertaken from the teachers involved. This was aimed at assessing the game's viability for effective integration within a classroom setting. The evaluation encompassed aspects such as student engagement, learning experiences, and the potential impact on student learning outcomes. Furthermore, this feedback-driven analysis sought to identify any inherent limitations and challenges associated with the practical implementation of the game within a classroom context.

Board Game Setup and the Feasibility of Use

Teachers found that the instructions for setting up and engaging with the game were clear and easy to follow. Nonetheless, they did mention potential challenges associated with familiarizing themselves with the devices and the app installation process. In this regard, educators indicated a preference for a combination of paper and video instructions, believing that such a multifaceted approach would enhance the ease of the setup procedure.

Furthermore, participants conveyed a shared sentiment that the gameplay itself was straightforward, attributing this ease to the utilization of dice rolls - a mechanism already well-versed to students. The Waka Hourua App was met with positive feedback for its user-friendly interface. Once initial guidance on device interaction was provided, participants exhibited comfort in navigating the 360-degree environments and utilizing the augmented reality (AR) cards effectively.

Teachers were also in favour of sharing one device per team and found sharing a single device with group of five was practicable. They viewed the experience as a valuable opportunity for the students to acquire skills in

collaboration and sharing.

Engagement

The participants expressed the game as enjoyable and engaging. One teacher said, “The children were so excited about the whole game and so keen to get to the next island.” In addition to that they stated, “It’s very high quality, informative and it’s colourful. This is our teaching handed to us on the plate.”

The teachers described the AR Cards as engaging as the AR cards presented 3D models, imagery, animation and sound in a new way. They also thought the questions on the cards add inquiry and learning. Catching fish with AR game appeared to add excitement and enjoyment to the game play as well.
While observing the 360 environments a participant stated “I love that you can look around and observe the night sky and interact with the waka. Kids love this type of stuff!”. The participants commented that students will be motivated to write about history after seeing and experiencing the game. Having a visual experience will give students words to talk about their thoughts on migration and will promote a sense of wonder about history. This shows that VR experience added a layer of enjoyment, interaction and learning.

Learning

Teachers described the effectiveness of the game in learning as, “The most effective learning is when it is in the form of a story, and or captures imagination. Having the multimedia in your game enhances opportunities for learning. When learning includes multi-sensory activities, it means it can reach more learners, as everyone has dominant learning styles. We experienced this when you allowed us to play with your board game.”
A teacher stated that “The 3D visual and audio experience provided education even without participants realizing that they are learning.” This indicates that the blended physical and digital interactivity can increase motivation and enjoyment for the user and provide an opportunity for students to interact, explore and learn.

The game supports learning in various ways such as collaboration, sharing, making choices, reading, group activities, visuals and audio. A participant pointed out that “When learning is offered in this way there is a depth and width to the learning. This helps the student to retain learning when it is attached to a number of areas as this helps them navigate through challenges easier”. One of the key advantages of mixed reality is that the information can be delivered in a few ways using various media and offers a variety of mediums and interactivity to support learning. As children learn differently, having information delivered in various mediums such as text to read, visuals, 3D models and videos to see and sounds to listen will help them learn in different ways, providing blended learning opportunities for students.

The inclusion of te reo Māori words within the game was noted to be particularly valuable, fostering both appreciation of the Māori language and cultural learning among students. While not exhaustive in its te reo instruction, the game introduces students to key Māori words, and the audiovisual components aid in pronunciation and retention. A Māori teacher underscored the game's significance in exposing students to Māori

words, thereby unlocking valuable learning pathways.

Additionally, the game aligns with Kaupapa Māori values such as aroha (love), manaakitanga (sharing), and kotahitanga (unity), further enriching its educational impact.

Challenges and Limitations

However, promising the application of mixed reality in education may be, several challenges and limitations were identified during this study.

A participant insightfully highlighted that the initial setup and familiarity with smart devices might pose a slight learning curve for both students and teachers. While not insurmountable, this adjustment period is a consideration. The consolidation of AR and 360-degree environments into a single app simplifies navigation; however, mastering the app's integration with the board game is essential for effective use. Therefore, additional usability testing is recommended to ascertain the app's user-friendliness for both students and teachers.

Managing multiple groups concurrently within a classroom setting emerged as another challenge. Teachers observed that orchestrating several groups engaging with the game simultaneously can be demanding. Some proposed a rotational approach, where groups take turns playing the game while focusing on other subjects in the interim. This scheduling strategy attempts to address the potential complexity of simultaneous group management.

Moreover, the time required to conduct a comprehensive gameplay session was acknowledged as a limitation. A teacher noted that allocating approximately an hour to play the game adequately could impact the overall classroom schedule. Balancing the game's immersive experience with other instructional requirements could necessitate careful time management.

In summary, while the potential benefits of mixed reality in education are evident, challenges such as device familiarity, managing multiple groups, and time allocation underscore the importance of iterative refinement and adaptation to ensure optimal integration within the classroom setting.

Conclusion

In summary, this study delved into the potential of Emerging Disruptive Technology, specifically Mixed Reality, as a tool to effectively teach the historical concepts of early Polynesian migration to primary school students in New Zealand. The findings of this study affirm that the utilization of mixed reality, particularly in the form of board games combining augmented reality and immersive 360-degree experiences, yields tangible benefits in creating collaborative, enjoyable, and impactful learning environments for primary school students.

The results underscore that mixed reality presents a fusion of digital and physical elements that cater to diverse learning styles. This amalgamation of media serves as a catalyst for student motivation, encouraging exploration,

reading, writing, listening, and active engagement. Through collaborative gameplay, valuable life skills such as patience, sharing, problem-solving, and teamwork are nurtured, all while upholding essential Kaupapa Māori values like aroha, manaakitanga, and kotahitanga.

The integration of augmented reality and 360-degree experiences facilitates learning through hands-on exploration and interactive engagement. The incorporation of 3D animated visuals, videos, and audio aids students in retaining information effectively. Notably, the inclusion of Te Reo words through audiovisual means promotes the learning of the Māori language among students.

This project can serve as a model for further exploration into the advantages of employing mixed reality to craft impactful learning experiences. The innovative board game concept can potentially extend beyond its current application, serving as a framework for the development of interactive media that can be employed as educational tools across various levels and subjects within academia.

Limitations

Curriculum Development: This research took place during the development phase of The New Zealand History Curriculum in collaboration with the Ministry of Education. The scope of the game and research was constrained by the available migration and voyaging topics outlined in the Social Science Curriculum and the Māori History Guidelines, as provided by the Ministry of Education.

Impact of COVID-19: The COVID-19 pandemic and its associated lockdown measures significantly affected the research process. Initial game tests were restricted to family and friends due to social distancing protocols, and subsequent trials and tests were similarly impacted. Additionally, interviews had to be conducted via Zoom in response to these restrictions.

Online Survey: The survey was conducted online, which may have resulted in responses primarily from teachers who actively utilize the internet and digital resources in their teaching practices. As a result, these findings may not be fully representative of different demographics and teaching communities across New Zealand.

Recommendations

Expand School Implementation: Extend the boardgame's implementation across diverse schools to reach a wider range of teachers and students.

Broaden Subject and Age Application: Consider utilising the mixed reality boardgame model across various subjects and age groups to explore its adaptability and potential in different educational contexts.

Embrace Emerging Technologies: Investigate the integration of emerging mixed reality technologies within educational settings to create enjoyable and engaging learning experiences for students.

References

Ministry of Education. (2023, February 10). *Aotearoa New Zealand's histories and Te Takanga o te wā*. Education in New Zealand. https://www.education.govt.nz/our-work/changes-in-education/aotearoa-new-zealands-histories-and-te-takanga-o-te-wa/

FINK, J. (2017). Virtual Worlds, Real Rewards. *District Administration*, *53*(6), 28–31.

Google Cardboard – Google VR. (n.d.). Google Cardboard. https://arvr.google.com/cardboard/

Graham, L. (2019, December 17). *The biggest tech breakthroughs of the last decade*. CityAM. https://www.cityam.com/biggest-tech-breakthroughs-of-last-decade/

Marjanen, Päivi & Mönkkönen, Ilkka & Vanhala, M.. (2011). Peer group learning during the board game sessions. Proceedings of the European Conference on Games-based Learning. 2011. 388-394.

Ministry of Education. (2015). *Te Ta* Ministry of Education. (2015). *Te Takanga o te Wa Maori History Guidelines For Years 1-8*. https://maorihistory.tki.org.nz/assets/Uploads/Te-Takanga-o-te-Wa-Maori-History-Guidelines-English-1.pdf

Freeman, A., Becker, S. A., & Cummins, M. (2017). *NMC/CoSN horizon report: 2017 K*. The New Media Consortium. https://www.learntechlib.org/p/182003/.

The official website of the New Zealand Government. (2019, September 12). *NZ history to be taught in all schools*. beehive.govt.nz. https://www.beehive.govt.nz/release/nz-history-be-taught-all-schools

Qianw. (2023, January 25). *What is mixed reality? - Mixed Reality*. Microsoft Learn. https://learn.microsoft.com/en-us/windows/mixed-reality/discover/mixed-reality

Schrier, K. (2006). Using augmented reality games to teach 21st century skills. *Association for Computing Machinery*. https://doi.org/10.1145/1179295.1179311

Squire, K., & Jan, M. (2007). Mad City Mystery: Developing Scientific Argumentation Skills with a Place-based Augmented Reality Game on Handheld Computers. *Journal of Science Education and Technology*, *16*(1), 5–29. https://doi.org/10.1007/s10956-006-9037-z

Ullman, E. (2017). Tech & Learning 2017'S Most Influential People in Edtech. *Tech & Learning*, *37*(10), 20–28.

Utami, I. W. P., Lutfi, I., Jati, S. S. P., & Efendi, M. Y. (2019). Effectivity of Augmented Reality as Media for History Learning. *International Journal of Emerging Technologies in Learning (iJET)*, *14*(16), pp. 83–96. https://doi.org/10.3991/ijet.v14i16.10663

Ministry of Education. (n.d.). *Voyaging / Tuia Mātauranga / Aotearoa New Zealand's histories / Social Sciences Online - eZSSOL*. Te Kete Ipurangi. http://ssol.tki.org.nz/Tuia-Matauranga/Voyaging

Author Information

Priyan Jayamaha

https://orcid.org/0009-0000-9505-456

Yoobee College of Creative Innovation

Level 4/3 City Road, Grafton, Auckland 1010

New Zealand

Contact e-mail: *priyanj@yahoo.com*