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Effectiveness of Projection Mapping Technology Development for Education

Abdillah Hanif Aulia Zulfikar Adha[1], Agus Juhana[2]
[1.2]Pendidikan Multimedia, Universitas Pendidikan Indonesia
e-mail:[1]abdillah1321@upi.edu ,[2]agus.juhana@upi.edu

Abstract

One of the main challenges that education will always face in the future is the change in teaching methods. Conventional teaching approaches and strategies are increasingly seen as less able to adapt to the digital society.The development of projection mapping in education opens up opportunities to create interactive learning experiences by transforming classrooms into visual media that support conceptual understanding. The purpose of this study is to find out how education uses projection mapping, the effectiveness of projection mapping in educating and find out what technologies are used. The research method used in this study is a systematic literature review (SLR) with a prism approach (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). The Prisma method provides a standard framework that improves quality in the process of systematic review and research replication. This shows that projection mapping is a very effective and innovative tool in creating immersive educational experiences in various contexts, including festivals, museums, and education, where video mapping has been shown to be able to convey messages in an interesting and easy-to-understand way through the combination of narrative, visual, and audio elements. Overall, projection mapping not only expands the boundaries of visual experience, but also offers a more effective and enjoyable educational method, and shows great potential to increase engagement, understanding, and appreciation of art, culture, and education.

Keywords-Projection Mapping, Education, effectiveness

1. INTRODUCTION

One of the major challenges that education will continue to face in the coming decades is the change in teaching methods. Conventional teaching approaches and strategies are increasingly seen as less able to adapt to the digital society. The educational model where a teacher simply reads material from a textbook, which students then have to memorize, test, and forget after the exam, is starting to be considered irrelevant [1]. Thus, educational methods need to be packaged through relevant and interesting media innovations to achieve effectiveness in learning. The use of innovative media allows learning materials to be delivered more interactively and can attract students' interest, thus encouraging involvement and increasing their understanding of the material being taught. Video mapping is one of the most effective media in conveying messages, in a similar way to other media such as sound, images, text, animation, and digital video manipulation [2]. However, what sets video mapping apart from other media is its ability to combine these visual elements directly with physical surfaces in the real world. This technology allows for the projection of images and animations onto three-dimensional objects such as buildings, walls, or other surfaces, creating the illusion of immersive and interactive visuals [2]. Video mapping (also known as 3D mapping, projection mapping, or simply mapping) is a special type of Augmented Reality (AR), a reality designed

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by developers [2]. Video mapping, also known as projection art, while projection art is a modern method of conveying information that uses visualization with the help of lighting and projection to create optical illusion effects on targeted objects [3] Not only that, projection mapping or video mapping is explained as a technology that allows the creation of visual illusions that appear real by combining audio and visual elements [4].

Video mapping, despite its short duration, is effective in conveying a message because it combines narrative, visuals, audio, and projections, creating an immersive experience with a three-act structure and visuals that highlight key elements of the story [2]. This technique has also proven effective in education [5], as it can transform public spaces such as buildings or streets into dynamic screens that present learning materials in a more engaging and understandable way. Video mapping enhances the interactive and immersive aspects to increase its effectiveness as an educational medium [6]. In addition to being an educational tool, projection mapping can also be a public advocacy tool, as demonstrated in Phaedra's research, which states that this technique is able to attract transnational attention, transform spaces into places of political engagement, and encourage collective imagination [7], thereby increasing awareness and encouraging constructive changes in attitudes regarding climate change issues [8].

In this study, the author uses the Systematic Literature Review (SLR) method to analyze previous research trends related to the use of projection mapping in the field of education. The SLR method was chosen to provide a comprehensive and structured review of relevant literature, allowing the identification of patterns, challenges, and opportunities in the use of this technology in education. By answering these three questions, the research is expected to provide a deeper understanding of the trends and effectiveness of projection mapping in educational media, as well as the technology that supports its implementation.

2. RESEARCH METHODS

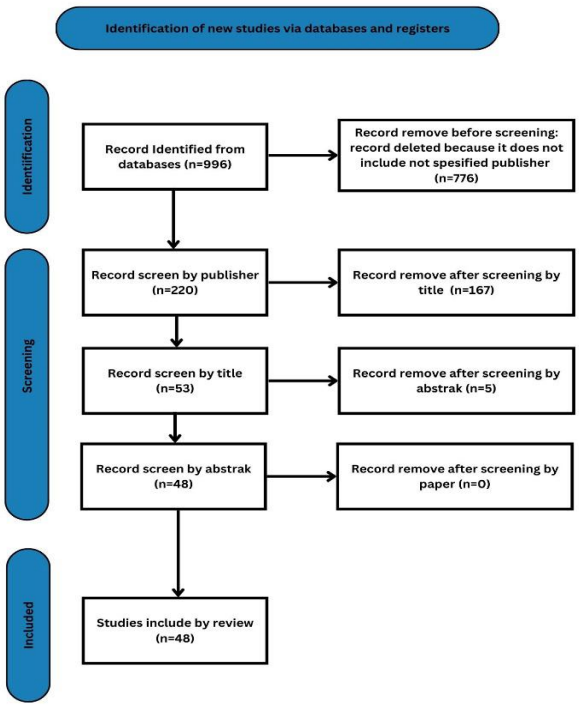

Figure 1. Prism Image

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The research method used in this study is a systematic literature review (SLR) with a prism approach (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). PRISMA provides a standard framework that improves quality in the process of systematic review and research replication.[9]. The main goal of PRISMA is to encourage transparent and complete reporting of systematic reviews, making it easier for other researchers to replicate or update previously conducted studies.[10]. This method was chosen to ensure that the literature review process is carried out systematically, transparently, and structured, so that the results obtained are more valid and reliable. The stages of research begin with the identification of relevant articles or literature. PRISMA is applied to increase transparency in reporting the results of systematic reviews, while providing PRISMA updates designed to allow researchers to make more comprehensive and accurate reports.[11]. Systematically reviewed and appropriately reported literature provides the strongest evidence to support clinical practice. Rigor in this process must always be aligned with relevance.[12]. This process is done through searching in various scientific databases, such as Google Scholar, using the keywords projection mapping & education that have been adjusted to the focus of the research. The purpose of this stage is to collect as much literature as possible related to the research topic.

2.1. Identification

Records identified from databases in the early stages, there were 996 articles successfully identified from various databases such as Google Scholar. Records remove before screening before the screening process began, there were 776 articles removed because they did not match the international publisher.

2.2. Screening

Next, screening of the literature that has been found is carried out. At this stage, researchers apply the inclusion and exclusion criteria that have been previously determined. Inclusion criteria can be topic relevance, publication time span, type of research, or others, while exclusion criteria can include literature that is duplicate, irrelevant, or does not comply with methodological criteria. The purpose of this stage is to ensure that only truly relevant literature is included in the next stage. Of the 220 articles, screening was carried out based on publisher, title, abstract and paper, so that the results of the screening in this study left 48 articles.

2.3. Included

The third stage is the evaluation of the eligibility of the literature that has passed the screening stage. Here, the remaining articles are evaluated in more depth based on the quality of their methodology, the validity of their data, and the relevance of their research results to the main research question. Researchers use critical evaluation tools to assess whether the article has sufficient scientific weight to be included in the final synthesis. At this stage, 48 articles remain.

2.4. Analysis & Synthesis

The final stage is data analysis and synthesis. Articles that meet the quality criteria are analyzed to identify key findings, common patterns, and research gaps. The results of these studies are then synthesized into broader conclusions about the topic being studied, providing a more comprehensive picture of the area.

3. RESULTS AND DISCUSSION

Based on relevant studies related to the use of projection mapping, it can be concluded that this technology is effective in supporting the educational process. These answers are based on information that has been collected from a literature review conducted on carefully selected articles. The author will examine each relevant finding, delving deeper into the context and significance of the existing research results. With this approach, it is hoped that it can provide a

clearer and deeper understanding of the issue being studied, as well as highlight the contribution of this research to the existing literature. Based on relevant studies related to the use of projection mapping in effective education in *What Forms of Education Do Other Researchers Conduct When Making Projection Mapping?*

Previous studies in the creation of projection mapping have developed various forms of education to support understanding and implementation. Several studies use educational approaches based on Workshops, Festivals, Museums, which allow for good and interesting information delivery. There are also theory-based approaches that provide basic knowledge about projection mapping technology, design techniques, and programming, so that participants have a more comprehensive understanding before practicing. In addition, several other studies emphasize project-based learning that encourages interdisciplinary collaboration, so that participants can understand how projection mapping can be applied in various visual contexts.

3.1 Festival

The NRMO video mapping by Lzy Visual, which was presented at the 2018 Jogjakarta Video Mapping Festival, is 3 minutes 30 seconds long, presenting a visual narrative with a three-act structure that includes an opening, climax, and closing. This structure helps the audience understand the storyline, which although short, successfully conveys messages about life, acceptance, never giving up, and self-reflection. The messages conveyed create an immersive experience that makes the audience feel calm and focused throughout the show [2].

3.2 Museum

Forms of education are not only limited to school lessons, but can also be found in various other contexts, such as in museums. In a museum environment, education can be presented through interactive experiences, which allow visitors to learn in a more engaging and immersive way, such as through the use of advanced technologies such as projection mapping to present information visually and immersively. An example of Projection Mapping at the FSJ-3D Printing Museum and a mixed media installation brings together 3D printing models, video mapping, and narratives about digital heritage. This installation is a key component in the permanent exhibition titled Virtual Journey through the History of Fort Saint Jean VJ-FSJ Project [13]. Not only that, Projection mapping Museo CajaGRANADA and Tate Liverpool Gallery and Museum collaborated in creating interactive digital images by utilizing selected artworks from their collections. This kind of mediation approach in an art museum is designed to deepen visual understanding and encourage art learning through the creation of artworks with a contemporary approach. Museo CajaGRANADA and Tate Liverpool Gallery and Museum collaborated in creating interactive digital images by utilizing selected artworks from their collections. This kind of mediation approach in an art museum is designed to deepen visual understanding and encourage art learning through the creation of artworks with a contemporary approach.[14]. The use of projection mapping in museums and galleries serves as an educational tool that enriches visitors' experience and understanding of artworks. This technology is an interactive tool that adds a visual dimension, allowing visitors to observe artworks in greater depth, often with additional information or visual elements projected onto the physical objects displayed. The goal is to encourage learning and enhance visitors' visual engagement, enriching their perception and insight into the cultural objects on display [15]. Projection mapping is also used to create an immersive cultural and spiritual experience by visualizing historical and architectural elements of the cathedral through augmented reality (AR) and virtual reality (VR) technologies, allowing visitors to access information that is not physically accessible and creating a virtual perception that is close to the real experience [16].

Not only museums, projection mapping by other studies is implemented in historical buildings where it becomes an educational media related to existing history such as in the study of Visual Engagement and Historical Accuracy in a Production for a Video Mapping Projection history validated by the history and education team. The results were projected on the historical building of Antigos Paços do Concelho in Viana do Castelo. Although not the main focus, an

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investigation was carried out after the event to assess the achievements of the project. Although without formal data, the project received a positive response and provided new knowledge about the history of the city and awareness of cultural heritage that can be explored further, with a focus on historical accuracy and detailed communication [17]. Another example of a historical building is the YEKPARE Project and the video mapping application at the Haydarpaşa Terminal during the Istanbul 2010 European Capital of Culture event showing how this technique is used to transform architectural structures into dynamic works of art, introducing a visual experience that combines cultural and historical elements with modern technology [18].

3.3 Workshop

Projection mapping physiotherapy lesson education is also a learning medium, namely Projection Mapping Augmented reality which utilizes body tracking to allow projection of anatomical structures and annotations directly on the moving body for the purpose of physiotherapy education. Through a design approach that focuses on users and learners, an understanding is formed that with the addition of annotations, this augmented reality technology can enrich physiotherapy education [19]. Projection Mapping in the workshop also discussed the use of projection mapping (sar) namely in two case studies that aim to strengthen the value of Contemporary Art and its educational foundations by using Spatial Augmented Reality (SAR), or known as video mapping, a performative act that allows the "addition" of content to existing elements [20]. Not only in the form of technology, projection mapping is often implemented into art. By holding the video mapping performance 'Topeng Hayat', it is hoped that the public, especially those who are teenagers and young adults, will get to know more closely one of Indonesia's original arts which is the distinctive identity of the city of Cirebon.[21]From this, projection mapping can be a means of attracting attention and restoring the values of art that have been increasingly fading. In the research Interactive Projection Mapping using Human Detection by Machine Learning which was raised [22]. projection mapping can create interactive projection mapping prototypes that not only entertain the audience but also the players, with a focus on sports. Through this technology, projecting objects such as balls to users, allows them to feel the sensation of a baseball pitch and lift the ball according to their movements.

As a continuation of the discussion on the form of education carried out by other research in the development of projection mapping, there are various applications that display innovation and variations of this technique. For example, in the context of the festival, the NRMO video mapping produced by Lzy Visual in the Jogjakarta Video Mapping Festival 2018 integrates visual narratives in a three-act structure to convey a profound message to the audience. In the museum environment, the use of projection mapping in mixed media installations connects 3D printing models with historical narratives, as seen in the Fort Saint Jean project. In addition, the collaboration between Museo CajaGRANADA and Tate Liverpool strengthens the art experience through interactive digital images that support visual learning. In the field of education, especially physiotherapy, projection mapping is used to project anatomical structures directly onto the user's body, enhancing understanding through the addition of annotations. From festivals to museums and education, the application of this technique shows the great potential of projection mapping in creating immersive and innovative educational experiences.

3.4. School

Projection mapping in schools is also discussed in a study entitled From Learning to Practicing– Our Education Methods of Teaching Projection Mapping developed by Qinglian, which is about making projection mapping including teaching the basics of design, computer graphics, and animation, as well as practical exercises with the necessary devices. Collaboration with external professionals is also carried out to expand students' skills and insights. Technologies such as Unity are used to connect elements in the work, teaching programming in the context of art. Evaluation and feedback are carried out to assess the effectiveness of learning and improve student understanding. Not only that, research related to the application of

projection mapping in physical education is also discussed in covering various forms of education, including the use of interactive technology to enhance the learning experience in the sports room through video projection (SAR), the application of exergames to enhance physical, social, and cognitive benefits, and interviews with physical education teachers to identify challenges and opportunities for implementing new technologies in large group teaching. In addition, the study also highlights assistive technology to support teaching and make technology more useful in physical education.

Video mapping is effective as an educational medium because it is able to convey messages in an interesting and easy-to-understand way. Combining narrative, visual, audio, and projection elements, this technique creates an immersive experience that helps the audience understand the material in depth, even in a short duration. NRMO video mapping by Lzy Visual Although short in duration, video mapping successfully conveys messages effectively through theoretical construction that includes narrative, visual, audio, and projection elements. These elements are important elements that enable the creation of an immersive and narrative presentation, with a three-act structure and visuals that strengthen the presence of the story [2]. Projection Mapping in dance education that has been applied and can be utilized in the development of dance wealth and dance creation includes mapping art, Virtual Reality (VR), Augmented Reality (AR), teleholographic, Paper Ghosts, digital platforms, and LMS. All of these technologies can be adjusted to the needs of users in the dance industry.

The implementation of Augmented Studio successfully enhanced the teaching and learning process in physiotherapy, by demonstrating the relationship between physiotherapy education and augmented reality technology through its ability to add elements and annotations [19]. The combination of Cirebon Mask Dance with video mapping offers a unique value, where the projection technique that produces optical illusions creates a direct interaction between the dancer and the visuals that is rarely found. This collaboration produces an interesting spectacle, enriched by aesthetic elements and elements of surprise. ArkaeVision provides interactive cultural experiences that leverage VR and AR technologies to enhance understanding and appreciation of cultural heritage through immersive learning, digital skills development, and emotional engagement, while also providing training for operators and guides, and gathering feedback for continuous improvement.

Virtual reality gives visitors privileged access to places that are off-limits to the general public in the cathedral, allowing them to explore spaces, statues, artifacts and relics in optimal conditions and create a tour that suits their desires and emotions. While the experience offered can feel as intense as that of a physical cathedral, there are concerns about the potential for the digital world to replace the real world, which could diminish the value of the physical space [16]. Projection mapping serves as an educational tool that connects culture and history by conveying legends and traditions through images and sounds, enhancing the value of monuments and narrative stories, while allowing for innovative delivery of historical context, despite facing technical challenges in rendering and testing the methodology. By integrating the coordinates of image objects in projection mapping, interactive prototypes designed to adapt to user movements have successfully entertained both spectators and players, such as when projecting a baseball to give the sensation of a throw, and surveys have shown that many people enjoy this experience.

In answering the research question regarding the effectiveness of video mapping in education, various studies indicate that this technique can convey information in an engaging and immersive way, using narrative, visual, and audio elements to create a deep and easy-to-understand experience. For example, NRMO video mapping by Lzy Visual is able to convey messages well despite its short duration. In addition, the application of technologies such as Augmented Studio in physiotherapy education has shown significant improvements in the teaching and learning process. The collaboration between dance and video mapping, as well as the interactive experience provided by ArkaeVision, further emphasizes that the integration of

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this technology not only improves the audience's understanding of the material being taught, but also creates emotional engagement and innovative educational experiences. The effectiveness of using projection mapping in education is seen in the improvement of student skills through interactive technology and collaboration with external professionals, as well as the application of technologies such as SAR and exergames to support learning experiences in various fields, including physical education.

In answering the question of the technology used in various projection mapping applications, this study focuses on the results of a comprehensive analysis, covering the latest innovations and applications of projection mapping techniques that have been explored in the context of schools, workshops, museums, and festivals. This study identifies how these technologies are effectively applied to create more immersive and interactive experiences, and have a positive impact on user understanding and skills in various fields.

1. First, in the context of the festival, the author refers to the NRMO video mapping by Lzy Visual which was presented at the 2018 Jogjakarta Video Mapping Festival. Here, video mapping technology is used to transform physical surfaces into dynamic projections that convey visual narratives in a three-act structure, creating a deep immersive experience for the audience.
2. Second, in the museum environment, the authors identify the use of mixed media installations that combine 3D printing models and video mapping with historical narratives. The Fort Saint Jean project is a prominent example, where these technologies are used to provide in-depth and interactive information about historical heritage.
3. Next, the author notes the collaboration between Museo CajaGRANADA and Tate Liverpool, where interactive digital images are applied to enrich the art experience. This approach encourages visual and immersive learning, using technology to create a stronger interaction between visitors and the artwork.
4. In the world of education, especially physiotherapy, the author highlights the use of augmented reality (AR) which allows the projection of anatomical structures directly onto the user's body. This enriches the learner's understanding through the addition of relevant annotations, increasing the effectiveness of the learning process.
5. The use of spatial augmented reality (SAR), which enhances the value of contemporary art in education by adding content to existing elements. It shows how this technology can be used to educate in an innovative and engaging way.
6. Interactive prototype with human detection in a sports context. This technology allows the projection of objects such as balls that respond to user movements, creating an interactive experience that not only entertains the audience but also actively engages them in the learning process.
7. Interactive Human Detection: In the context of sports, this technology is used to create projection mapping prototypes that entertain spectators with projections of objects such as balls, according to the user's movements.

By analyzing the various findings, a comprehensive picture can be drawn up of the various technologies applied in projection mapping and its very broad application in various fields, such as festivals, museums, art, and education. This technology has enormous potential to create educational experiences that are not only immersive, but also innovative. Its application allows for the creation of new ways of understanding and appreciating art, culture, and enriching learning experiences in various sectors. This shows how projection mapping can change the way we interact with information and creative works in a more interactive and immersive context.

Projection mapping technology used in various previous studies leads to its application in the context of education. Education itself is not limited to schools, but also includes various other forms such as museums, workshops, and others. Thus, there are many developments in

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projection mapping technology that continue to be carried out to support the education process in various sectors.

1. Projection mapping-based interactive picture books enhance the reading experience by projecting dynamic visual elements and illusions onto the book pages, creating immersive effects of movement and transformation.
2. OptiSpace optimizes automatic projection mapping content placement by analyzing user viewing behavior and evaluating visual quality in a variety of uncontrolled environments.
3. The MR-based AR/VR concept introduces an immersive and participatory art learning method that combines art history experience with creative art creation using modern technology.

4. CONCLUSION

This research shows that projection mapping is a highly effective and innovative tool for creating immersive educational experiences in a variety of contexts, including festivals, museums, and education, where video mapping has proven to be able to convey messages in an engaging and understandable way through the combination of narrative, visual, and audio elements, as demonstrated by Lzy Visual's NRMO project which encapsulated major themes in an organized structure to provide better understanding to viewers. In addition, other research shows a variety of projection mapping applications, from arts festivals creating powerful visual narratives to increasing interactivity in museums and innovative delivery of learning materials in education, particularly in physiotherapy. The various technologies used, including video mapping, augmented reality (AR), and spatial augmented reality (SAR), enrich the visual experience and allow for content to be tailored based on user interaction. Overall, projection mapping. In the school context, the use of projection mapping in education has proven effective in improving student skills, enriching learning experiences through interactive technologies, and supporting teaching in a variety of areas, including physical education, with the application of technologies such as SAR and exergames.

5. SUGGESTIONS

Suggestions for further research include an in-depth analysis of the impact of projection mapping as an educational medium, particularly in enhancing visual engagement and comprehension. Research can explore the extent to which projection mapping affects knowledge retention, learning interest, and how this medium supports interactive learning compared to conventional methods. In addition, it is important to evaluate potential barriers, such as accessibility and implementation costs, to provide practical guidance on the use of projection mapping in various educational contexts.

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and the wider community. Hopefully this support will have a positive impact that continues and becomes an inspiration for future research.

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