A Study on Development of Low-Cost 3D Scanning for Archiving 3D Artworks

Muhammad Sukor Romat[1*], Noor Azzanny Jamaludin[2], Mohd Iqbal Badaruddin[3], Mohd Ifwat Mohd Ghazali[4], Farid Raihan Ahmad[1], Mohd Ifwat Mohd Ghazali[5]

[1]College Of Creative Arts, Universiti Teknologi Mara, 40450 Shah Alam, Selangor, Malaysia.

[2]Faculty Of Education And Humanities, Unitar International University, 47301, Kelana Jaya, Selangor, Malaysia

[3]Department Of Liberal Studies, College Of Creative Art, Universiti Teknologi Mara Kelantan (Machang Campus), 18500, Bandar Machang, Kelantan, Malaysia

[4]Smart Rg, Faculty Of Science And Technology, Universiti Sains Islam Malaysia (Usim), 71800, Nilai, Negeri Sembilan, Malaysia

[5]Department Of Engineering, University Of Cambridge, Trumpington Street, Cambridge Cb2 1pz, United Kingdom

***Corresponding Author**

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ABSTRACT

3D scanning technology plays a vital role in capturing complex data that is otherwise difficult to obtain. It enables detailed scanning of objects and environments, facilitating thorough analysis and visualization. In education, 3D scanning has transformed the learning experience by allowing students to interact with three-dimensional objects, thereby enhancing their understanding of complex concepts. Additionally, 3D scanners address space constraints while delivering high-quality images for digital archiving and documentation of artwork.

Acquiring a 3D scanner from the market is nearly impossible for students and individuals from low-income backgrounds. Therefore, the primary objective of this research is to develop a method to create low-cost 3D scanning technology, specifically designed for archiving student artwork. This study also proposes solutions for the effective documentation of student artwork. The research involves experimental studies, observational methods, and discussions, with results documented through photographs, videos, and notes.

The researchers tested the feasibility of low-cost 3D scanning technology for archiving artworks created by students at the College of Creative Arts, Universiti Teknologi MARA (UiTM) in Shah Alam and Machang campuses, successfully identifying an effective approach to developing this low-cost 3D scanning technology. The findings indicate that 3D scanning technologies are vital in fostering innovation and driving progress across various fields, with a significant impact on education.

Keywords: Low - cost; 3D Scanning; 3D Artwork; Archiving; User - Friendly technology

INTRODUCTION

Due to the intricate nature of the medium, preserving artworks created by students who produce three-dimensional (3D) pieces poses a significant challenge. Capturing the fine details and nuances of 3D art requires specialized preservation techniques and documentation methods. While digital images of two-dimensional

(2D) artworks can be easily stored and appreciated, images of 3D artworks often fall short, as they capture only a single perspective of the piece.

Displaying artwork in 360 degrees allows viewers to better appreciate the full form and complexity of 3D shapes. Additionally, storing physical 3D artworks as collections requires considerable space, which is often impractical. According to Hemsley et al. (2017), a modern approach to this challenge involves using technology to create archival records or digital 3D models of essential museum objects. This method is becoming increasingly necessary in today's digital world, as 3D digital files offer the advantage of being stored indefinitely, unlike traditional physical artworks.

However, acquiring a 3D scanner requires a substantial budget, which many institutions and individuals may not afford. This limitation poses a significant challenge, particularly for smaller museums, educational institutions, or individuals who wish to adopt this innovative approach. Moreover, scanning and creating digital 3D models can be time-consuming and often requires specialized knowledge, further complicating the adoption of this technology.

This research paper explores the development of low-cost 3D scanning technology specifically designed for archiving student artwork. The objective is to create an affordable and accessible solution for educational institutions, enabling students to document and preserve their artistic creations in a three-dimensional digital format.

The significance of this research extends beyond merely providing a solution for archiving student artwork. It aims to develop alternative methodologies for the preservation, study, and interpretation of 3D artwork. This initiative seeks to enhance educational practices by fostering greater engagement, accessibility, and a progressive approach to learning, particularly in the field of fine art.

Aim and Objective

This research aims to develop a low-cost 3D scanning technology for archiving artwork created by =students at the College of Creative Arts, Universiti Teknologi MARA (UiTM) Shah Alam. The main objectives of this study are:

To create a suitable method for developing a low-cost 3D scanning technology process for archiving artwork created by students at the College of Creative Arts, Universiti Teknologi MARA (UiTM) in Shah Alam and Machang campus.

To provide solutions to the archiving documentation system for artworks by students at the College of Creative Arts, Universiti Teknologi MARA (UiTM) in Shah Alam and Machang campuses.

LITERATURE REVIEW

3D scanning technology is widely used in industries such as industrial design, engineering, education, and manufacturing due to its ability to quickly and accurately capture essential data (Dusan, 2019). This technology involves capturing the shape of a physical object and creating a 3D model using a 3D scanner (Straub et al., 2014). With advancements in technology, 3D scanners have become indispensable tools across various fields. They allow objects or products to be scanned and converted into 360-degree images effortlessly. Affordable 3D scanners are now widely utilized in education, archaeology, geography, interior design, and personal use. By employing low-cost, ready-to-use equipment and computer software, 3D scanners can be developed using various methods, including laser light or cameras. This technology reduces the costs and time required for scanning processes, recording, and analyzing three-dimensional artwork, particularly in teaching

and learning. Not only does 3D scanning enhance the learning experience, but it also provides students with a deeper understanding of three-dimensional objects (Christian et al., 2019).

The emergence of low-cost 3D scanners represents a significant advancement in technology, building upon prior research that extensively explored and debated the development of diverse methods, materials, and software specifically designed for manufacturing 3D scanners (Besl & McKay, 1992). These studies have contributed significantly to the progress and optimization of 3D scanning methods and techniques, utilizing tools such as Time of Flight, Phase Shifting, Triangulation, Laser, Optical, and Fringe Projection. Software platforms like Microsoft Kinect, Windows, Linux, and Mac OS X have also been employed in these studies (Nielsen et al., 2019). Advancements in current technology have enabled further research into integrating 3D scanners into production processes using cost-effective and time-saving materials (Nielsen et al., 2019). However, the manufacturing and maintenance of traditional 3D scanners require high-quality materials and significant investment, with estimated costs ranging from USD 3500 to USD 5000, including equipment and software (Straub & Kerlin, 2014, pp. 82–83). These costs, combined with their large footprint, have limited 3D scanner applications to specific industries such as medicine, construction, geography, and automotive (Straub & Kerlin, 2014).

Archiving artwork has traditionally involved thorough physical documentation, including handwritten inventories, detailed descriptions, sketches, photographs, and illustrations of artworks. These physical documents were essential for identifying the provenance, condition, and historical significance of the artwork. However, using traditional methods for archiving artworks introduces several challenges. Materials like paper documents, photographs, and storage containers are prone to physical degradation over time. Factors such as light exposure, fluctuating humidity, pests, and handling can cause deterioration, compromising the integrity of the archived information (Nielsen et al., 2019).

Moreover, access to archived materials can be limited by factors such as location, visiting hours, and institutional policies, creating barriers for students and researchers. Physical archives also require dedicated storage spaces, which can be costly and have limited capacity. As art collections grow, institutions may struggle to accommodate additional archival materials, leading to overcrowding and suboptimal storage conditions. Furthermore, physical archives are vulnerable to risks such as theft, fire, water damage, and natural disasters. Despite protective measures, the loss or damage of these materials can result in the irretrievable loss of valuable artworks (Nielsen et al., 2019).

The connection between archiving artwork and 3D scanning offers significant benefits for both fields. 3D scanning serves as a powerful tool, enabling the creation of highly accurate digital archives. These digital archives are particularly valuable for preserving student artwork at universities, as they capture every intricate detail of the artwork in three dimensions. Additionally, digital archives created through 3D scanning can be easily accessed, stored, and shared, facilitating broader dissemination of artworks and creating greater opportunities for collaboration and research. Overall, the integration of 3D scanning into archival practices has the potential to revolutionize the preservation and study of art in academic settings, offering innovative solutions to traditional challenges.

METHOD

Research Design and Approach

Observation methods are a way of collecting data directly from sources at the locations being visited. The aim is to identify and document observations accurately. This research involves an experimental study and discussion, with results documented using photographs, videos, and notes. The objective of this study is to create an affordable 3D scanning technology solution that can be used to archive student artwork at the College of Creative Arts, UiTM Shah Alam, and Machang campuses.

Process of Developing Low–Cost 3D Scanning Technology System Design Hardware Structure

The process of developing a low-cost 3D scanning technology for hardware is divided into two parts, namely the Kinect Stand and the Turntable Platform. The proposed design for the Kinect stand consists of a Microsoft Xbox 360 Kinect, a power supply cable, a USB adapter for the Microsoft Xbox 360 Kinect sensor, and an extension cable for the Xbox 360 Kinect sensor. Other 3D printer parts include the 2040 Y-axis synchronous belt tensioner and the 2080 sliding plate pulley for 2080 V-groove aluminum extrusions and 2040 V-groove aluminum extrusions. The stand used hollow 4040 mild steel for a custom Kinect stand that is easily removable for mobile use. The 3D-printed custom fishing reel seat was was designed to secure the Kinect sensor along with the stand. This Kinect stand allows the Kinect sensor to move up and down smoothly, using the fishing reel to pull, lock, and release.

Design Process

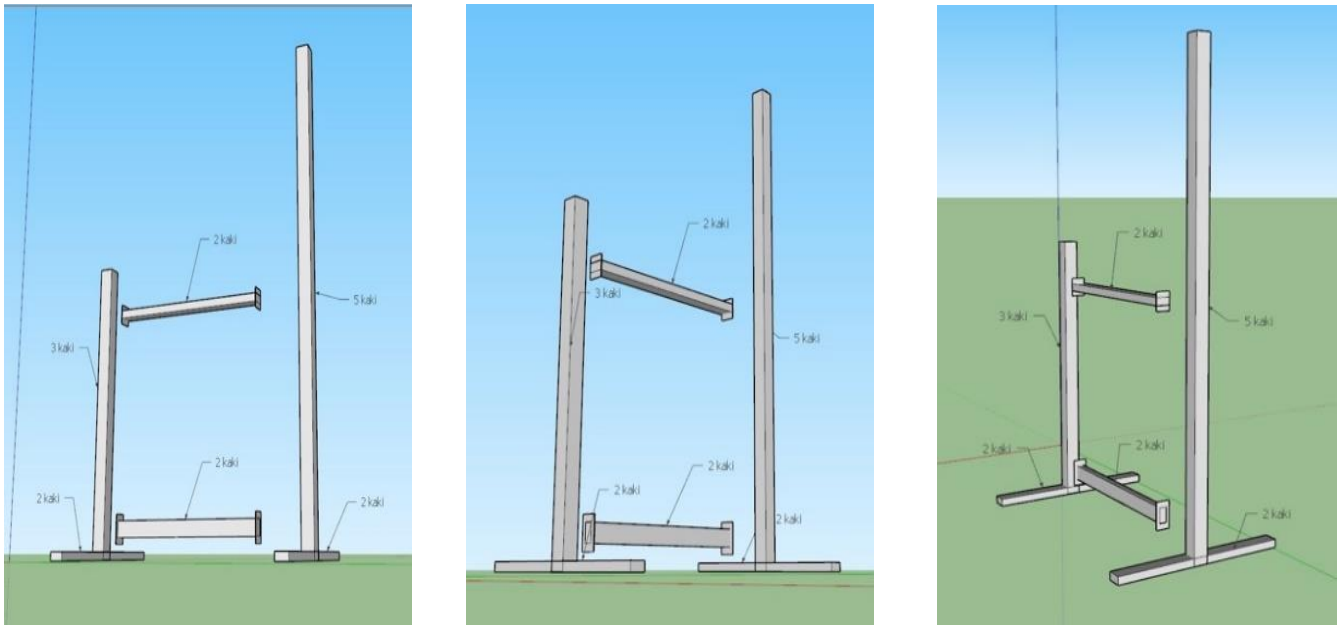

Fig. 1: Design Process using Sketchup software to build up low-cost 3D scanning (Source, Muhammad Sukor Romat, 2024).

The turntable platform solution consists of an 18mm thick plywood base platform, timing belt rubber made from 3D printer parts, a front wheel bearing hub, a DC power supply unit, a mini worm gear motor, and a DC motor speed controller. Custom gear for the gear motor was 3D-printed to align with the timing belt rubber. The worm gear motor is capable of supporting artwork weighing up to 100kg. The rotational speed can be adjusted using the DC motor speed controller, allowing for smooth 360-degree scanning without any obstacles. Additionally, the turntable platform can be easily detached for mobile use.

Hardware Structure

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Software

The software used in this project is SKANECT 3D scanning software from the Occipital Company. SKANECT is compatible with sensors such as the Xbox 360 Kinect. It is easy to use and can recreate tangible objects as a computerized 3D model. This software is available in a free version for non-commercial use, and the Pro version costs about USD 130. SKANECT can turn the Xbox 360 Kinect into an affordable 3D scanner that can create 3D meshes from natural scenes in just a matter of minutes.

System Development

System Operation

Adjustments were made to the Kinect stands and turntable platform. The position of the Microsoft Xbox360 Kinect sensor istarts at the top and moves down gradually, while the turntable platform slowly rotates, and the artwork is positioned in the center of the platform. The first person operates the SKANECT software from the laptop, and the second person controls the movement of the Microsoft Xbox 360 Kinect using the fishing reel on the Kinect stand. This process is repeated for filling in missing sections or realigning the last scan position. The first person checks and determines the scans that need to beperformed. Once the scan is complete, the file is saved to a folder or shared via the cloud system.

Fig. 2:The low-cost 3D scanning which has Kinect stands and a turntable platform (Source, Muhammad Sukor Romat, 2024).

RESULTS AND DISCUSSION

In this study, the 3D scanners available on the market were analyzed by comparing their costs and the materials used to build the low-cost 3D scanner.

Costing for Low–Cost and Others 3D Scanning

Kinect Stand Cost

Table 1: Costing for Low-Cost 3D Scanning

No.	Item Used for Low-Cost 3D Scanner	Shop	Low-Cost3D Scanner Price
1	2040 Profile Y-axis Synchronous Belt Stretch -3D Printer Parts	www.aliexpress.com	RM 17.22
2	V Gantry Plat Set Special Slide Plate Pulley for 2080 V-Slot Aluminium Profiles with Six Wheels	www.aliexpress.com	RM 51.48
3	EU Power Supply Cable Cord Adapter USB for Microsoft Xbox360 Kinect Sensor	www.shopee.com.my	RM 16.90
4	Kinect Sensor Extension Cable for Xbox 360	www.shopee.com.my	RM 24.10
5	Xbox 360 XBOX360 Kinect Sensor and Power Adapter Kit	www.shopee.com.my	RM 220.00
6	2040 V-Slot Aluminium Extrusions	KosanAluminium Extrusion Sdn. Bhd.	RM 193.50
7	4040 hollow mild steel 2’’x2’’x1.3mm (5 Feet’s)	www.shopee.com.my	RM 126.00
8	DEUKIO Fishing Reel	www.shopee.com.my	RM 37.30
9	Mild Steel Pipe 27mm (Dia) x 2.3mm x 4 Feet	www.shopee.com.my	RM 22.00

Turnable Platform Cost

No	Item Used for Low-Cost 3D Scanner	Shop	Low-Cost3DScanner Price
1	2PCS/Lot Timing belt closed loop rubber GT2 2270 teeth 1135 length 2270mm width 12mm-2GT 3D printer	www.aliexpress.com	RM 35.70
2	Front Wheel Bearing Hub - Honda Accord SM4 SV4	www.shopee.com.my	RM 100.80
3	ASLONG Micro voltage transformer from Ac 220V 50HZ to dc 24v 15A AND AC 100V 60HZ to dc 24v 15A dc power supply for dc motor	www.aliexpress.com	RM 111.57
4	24V 100kg.cm Mini Worm Gear Motor high torque right angel motor worm gear motor good quality metal reducer box with dc motor	www.aliexpress.com	RM 183.93
5	Enclosed dc governor DC Motor speed controller 10-60v CW/CCW Max current	www.aliexpress.com	RM 72.61

	6A 12v dc gear motor 24v high torque gear motor J909		
6	(4FT x 8FT) 18MM Panel Wood Board Sheet Plywood (2 pcs)	www.shopee.com.my	RM 365.06
Total			**RM 1578.17**

Costing for Others 3D Scanning

Table 2: Costing for Others 3D Scanning

No.	**3D Scanners in Market**	**Shop**	**Low-Cost 3D Scanner Price**
1	Shining 3D Ein Scan-SP Desktop 3D Scanner 3D Scanning for 3D Printer	www.shopee.com.my	RM 14,500.00
2	Shining3D Ein Scan Pro 2X Plus Handheld 3D Scanner	www.shopee.com.my	RM 35,800.00
3	3D Scanner Free Scan X3/X5/X7 Handheld 3D Laser Scanner High-Precision Industrial-Grade Modelling 3D Product Mapping	www.shopee.com.my	RM 82,045.00 to RM 125,379.00

Upon scrutinizing available options, it has been ascertained that this cost-effective 3D scanner is priced at RM 1,613.87, signifying a noteworthy cost advantage compared to other 3D scanners on the market.

Comparison Scanner Result

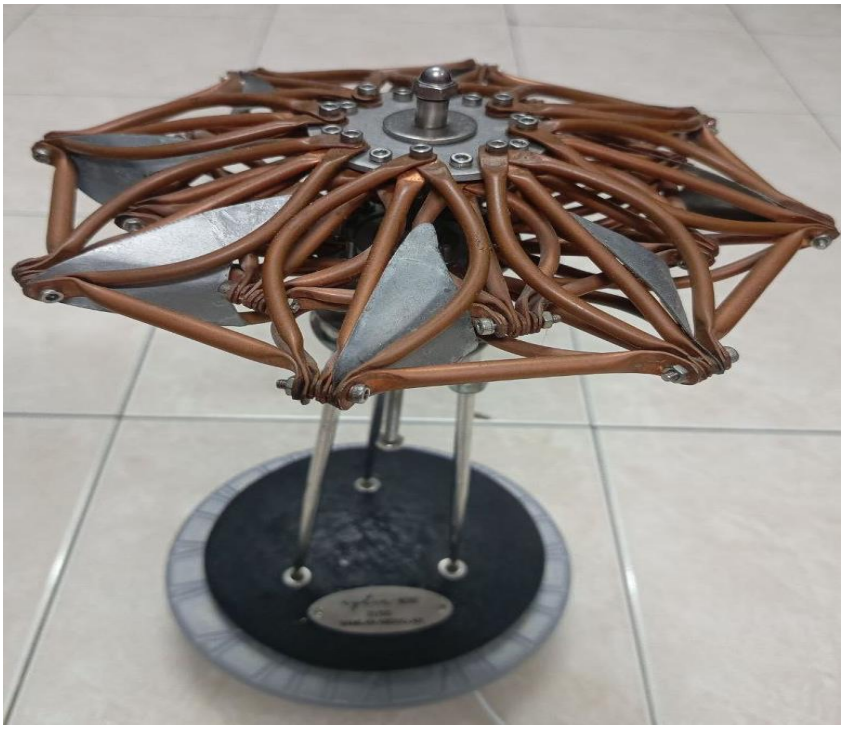


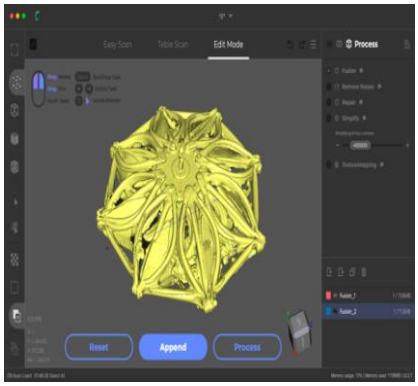
Fig. 3 : An actual sculpture artwork entitled ‘Ayden’(Source, Muhammad Sukor Romat, 2024).

The sculpture adeptly integrates components crafted from stainless steel, aluminum, and metal, yielding a compelling composition that captivates the observer and sparks the imagination. The intricate amalgamation of materials and meticulous attention to detail make it an excellent candidate for our investigation into 3D scanning technologies.

The following are the differences between scanner results: low-cost 3D scanning and Cr-Scan Lizard 3D Scanner By Creality 3D.

Table 3 : Comparison Scanner Result

3D Scanner Type	Image	Description
Low-Cost3D Scanner	 	The resolution (i.e., the amount of detail the scanner captures) of the Microsoft Xbox 360 Kinect scanners is often limited, despite their notable data collection capabilities. Scanned objects and surfaces frequently have rounded edges that appear to have been smoothed down. Low-cost 3D scanners provide a satisfactory level of precision, making them acceptable for fundamental scanning requirements. Due to their lower resolution capabilities, these scanners can capture details at a significantly diminished level compared to more costly scanners. Additionally, the scanning speed is relatively slow. In terms of compatibility, these scanners may have limitations, especially in software and hardware integration. Users may find that the scanner is primarily compatible with Skanect software, potentially limiting their options for post-processing and editing. While it lacks the advanced features of higher-end models, this scanner provides an entry-level option for those with moderate scanning needs.
Cr-Scan Lizard 3d ScannerBy Creality 3D		These expensive 3D scanners are designed to deliver excellent results, offering high precision that meets the demands of professional-grade projects. With higher resolution capabilities, these scanners excel at capturing intricate details with precision, ensuring that even the smallest features are rendered accurately. Their fast-scanning speed significantly reduces the time it takes to complete a scan, making it ideal for time-sensitive tasks and large-scale projects.

		One of the standout features of this scanner is its versatility in scanning volume. It can accommodate both small and large objects with ease, thanks to customizable options that cater to a wide range of project sizes. Additionally, its compatibility with industry-standard software and hardware, especially from Creality, ensures seamless integration into existing workflows. This opens up a world of possibilities for post-processing, editing and collaboration, empowering users to unleash their creativity without limitations.

Example of student's artwork

Fig. 4. An actual sculpture artwork entitled 'Motif Buah Anyam' from graduate student at the College of Creative Arts, Universiti Teknologi MARA (UiTM) Shah Alam (Source, Muhammad Sukor Romat, 2024).

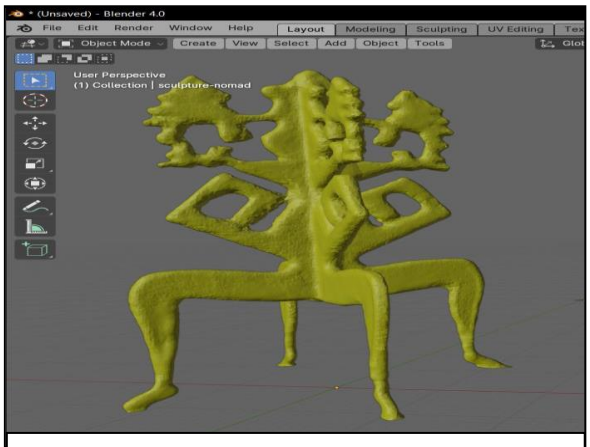


Fig. 5. Result of scanning sculpture artwork using low-cost 3D scanning. (Source, Muhammad Sukor Romat, 2024).

The picture above shows a comparison between the actual student's sculpture (Fig. 4) and the scanning result (Fig. 5) using a low-cost 3D scanner. The actual sculpture, Motif Buah Ayam, was created by a graduate student from the Department of Fine Art, College of Creative Arts, UiTM Shah Alam. The sculpture features intricate details at the top (head) and a rustic texture with natural tones of brown and gray. This freestanding sculpture exhibits an aged surface with rough textures, reflecting its title, Motif Buah Ayam, which relates to current societal issues. Using metal as the primary material, the artist crafted four identical forms resembling a woman's leg wearing heels.

Through this comparison, the scanned image demonstrates the effectiveness of the low-cost 3D scanner. The digitized version, displayed in Skanect software, appears in a single color and can be viewed in a 360-degree turnaround. It represents a typical raw three-dimensional mesh file without any textures. While the colors

differ, the scanning process was still able to accurately replicate the sculpture's shapes, curves, and intricate patterns with approximately 95% realism.

In comparison, both images show identical structures, successfully generating a three-dimensional scanned image. The original sculpture serves as a reference for 3D modeling artwork, while the digitally scanned version effectively captures the entire sculpture in Skanect with a 360-degree view. However, the scanned 3D image lacks detailed textures and displays only a monochromatic yellowish color. Despite this limitation, the effort highlights the effectiveness of 3D scanning technology as a tool for preserving three-dimensional art, particularly those featuring intricate forms. This demonstrates the potential of 3D scanning technology for the documentation and archiving of three-dimensional artworks or products, encouraging further adoption of digital preservation methods.

Analysis

In this study, a total of 100 students from the College of Creative Arts, Universiti Teknologi MARA (UiTM) Shah Alam and Machang campuses were actively involved. The analysis focused on evaluating two key aspects: first, assessing the practicality of using low-cost 3D scanning technology and second, recommending the use of low-cost 3D scanning technology in the future for educational purposes.

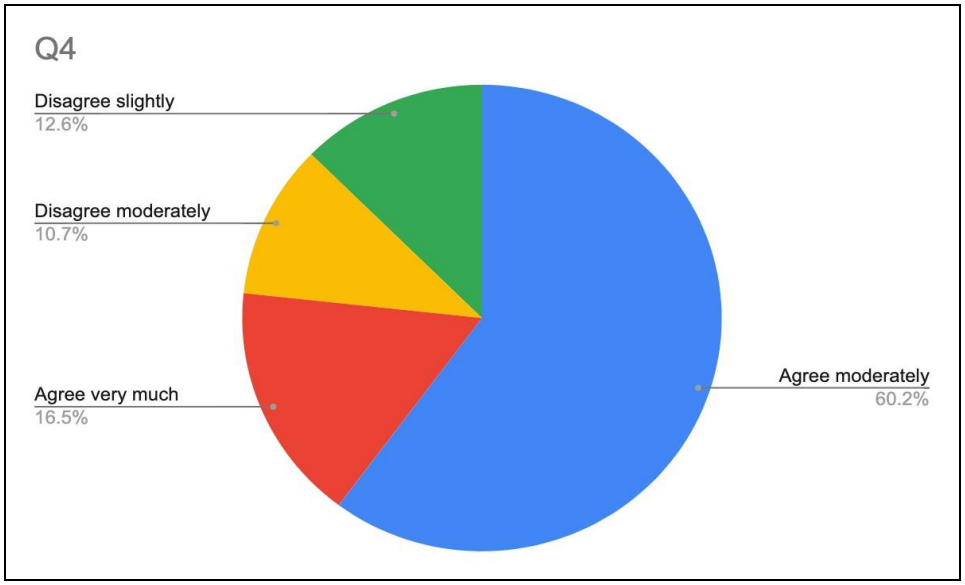


Fig. 6: Analysis on the Usefulness of Low – Cost 3D scanning.

Figure 6 shows the results based on Question Q4, which focuses on the usefulness of a low-cost 3D scanner in assisting students with collecting data for three-dimensional artworks digitally. The survey revealed that 60.2% of respondents found the scanner to be "useful," while 16.5% indicated they "agreed" with its usefulness. In total, 76.7% of respondents acknowledged the usefulness of 3D scanning technology in generating three-dimensional images from 3D artworks, indicating a predominantly positive response.

The remaining respondents expressed varying levels of disagreement, which were split between "moderately disagree" and "slightly disagree" regarding the scanner's usefulness. Combined, these categories accounted for 23.3% of respondents who were not satisfied with the technology, primarily due to its limitations in capturing the full texture and intricate forms of the artwork. However, it was noted that the generated three-dimensional images can still be revised and refined, particularly the surface details (or "skin"), using appropriate software tools.

This highlights the potential of low-cost 3D scanners, despite their weaknesses, in supporting students' efforts to digitally archive and document three-dimensional artworks.

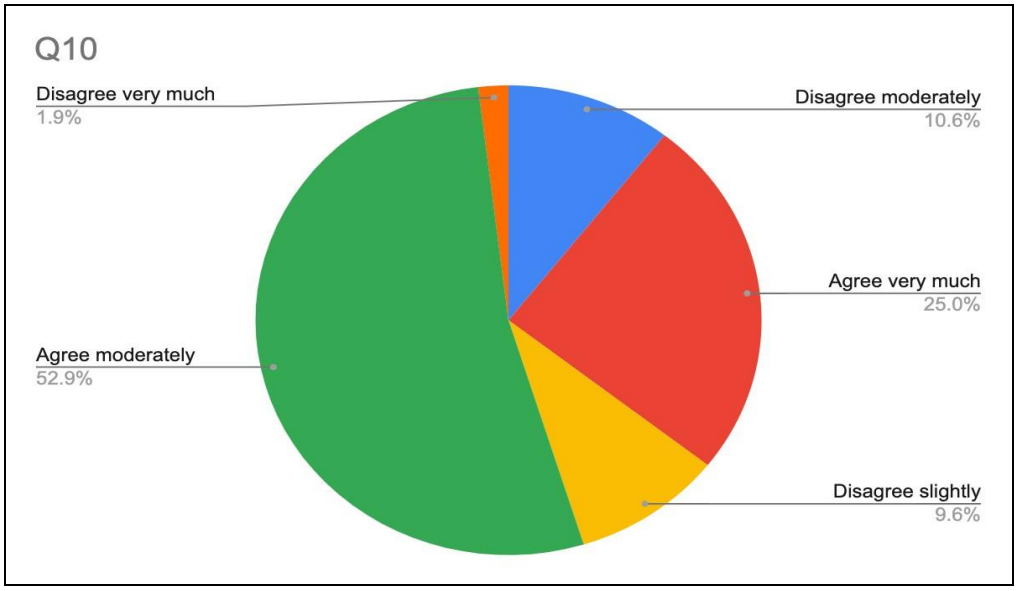


Fig. 7: Analysis on using Low – Cost 3D scanning technology for education and future references.

Figure 7 displays the results of using low-cost 3D scanning technology in education and for future references, particularly for archiving purposes. A significant proportion of students, specifically 52.9%, "agree moderately," while 25% "agree" regarding the future use of low-cost 3D scanning technology. Additionally, 1.9% of students "disagree," 10.6% "disagree moderately," and 9.6% "disagree slightly."

The results still demonstrate a majority of users, totaling 77.9%, who prefer to use this technology for future reference due to its value in archiving purposes. In contrast, 22.1% of respondents expressed disagreement, citing weaknesses such as the size of the scanner, the complexity of the software, and the limited number of students skilled in conducting the scanning process, as well as refining and transferring the data digitally.

Based on these results, it can be interpreted that most students from CCA UiTM Shah Alam and Machang campuses adapt quickly to current technology, particularly in scanning three-dimensional artworks for archiving. The author assumes that taking pictures using a cellphone camera can only generate two-dimensional images but not three-dimensional data. By utilizing 3D scanning technology, students are better equipped to conduct comparative studies on their 3D artworks for future reference. This technology also aids in improving their skills in creating high-quality freestanding sculptures or other 3D art forms, such as motion design, architecture, or product design.

CONCLUSION

During the process, the researchers successfully tested the feasibility of low-cost 3D scanning technology for archiving the artworks of students at the College of Creative Arts, Universiti Teknologi MARA (UiTM) in Shah Alam and Machang campuses. The results indicate that while low-cost 3D scanners provide a promising solution for creating digital archives, their accuracy remains limited due to factors such as component quality and software calibration.

For example, scans created with SKANECT were able to capture the overall shape of objects but often lacked precision, making them unsuitable for applications requiring exact measurements. Post-processing challenges, such as removing unwanted surfaces, filling gaps, and realigning scans, further underscore the limitations of these scanners, particularly when dealing with smooth or flat surfaces.

Nevertheless, low-cost 3D scanners represent an excellent entry point for introducing students to 3D scanning technology. In this study, the scanners enabled students to digitally preserve their artwork while gaining practical exposure to the 3D scanning process. Despite limitations in detail and accuracy, the technology

successfully demonstrated its value in fostering an understanding of three-dimensional concepts and enhancing students' technical skills in digital preservation and archiving.

To fully harness the potential of low-cost 3D scanning technology, further research is needed to explore its integration into fine arts education. By evaluating the perceptions of students and lecturers, identifying specific challenges, and developing targeted solutions, such research can contribute to the adoption of innovative teaching methods. Ultimately, low-cost 3D scanning holds immense promise as a tool for democratizing access to digital preservation technologies, improving educational practices, and paving the way for enhanced creativity and artistic innovation.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest regarding this manuscript.

CONTRIBUTION OF AUTHOR

All authors are participants in the data collection and analysis and writing and revising the manuscript.

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