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Evaluation of the Visual Learning Application for Mathematics using Holography Display for the topic on Shape and Space

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***Abstract*— Mathematics is an important foundation in the life of an individual. The problems associated with learning Mathematics that are commonly encountered, are due to factors such as: abstract phenomena and concepts, low imagination, and lack of understanding of the concepts being studied. Thus, the purpose of this study is to help primary school children improve their ability to recognise 3D shapes that are abstract phenomena. This paper presents the Effectiveness Usability Evaluation of the Visual Learning Application for Mathematics using Holography Display for the topic on Shape and Space called MEL-VIS. This study was conducted on eighty (80) primary school students. The results of the study showed that learning about 3D shapes with the E-Visual MEL-VIS application prototype is more effective than traditional methods.**

***Keywords*— Tablet technology; multi-touch technology; hologram; visual learning; shape and space.**

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I. Introduction

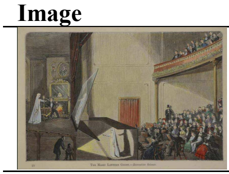
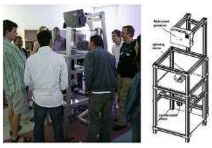
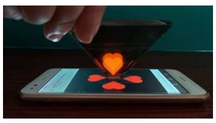
Education has always evolved in respond to changing demands and needs. During the COVID-19 pandemic, it is necessary for teaching and learning to take place digitally and remotely. According to an article published by Online Daily News on April 25, 2021, by Zainuddin [1] describe CERDIK as a long-term effort that provides digital access to education and is comprises of two (2) primary components: access to device connection and data. This initiative is a joint effort between Ministry of Finance (MOF) and the Ministry of Education (KPM), to narrow the digital learning gap in Malaysian primary and secondary schools. Not to only run a gadget donation programme in the short term, CERDIK will investigate digital learning models with an eye toward future application. The following is a statement that was made by Datuk Radzi Jidin, the Senior Minister of Education: “CERDIK is a pioneering digital learning programme, and it was introduced at the opportune moment, when digitalization is quickly spreading in many facets of society's everyday life," In this day and age, digital transformation has in fact developed into an absolute must. As we can see, the catastrophe caused by COVID-19 outbreak has made it quite evident that digitalization is necessary. Virtual learning has been vital all over the globe to make sure that schooling is not disrupted, and that education may continue.” Source: [1]. Therefore, emerging technologies such as holograms, multi-touch, and the internet of things play a significant part in the success of online learning and virtual learning.

Education covers a wide range of fields and subjects. Schools typically include mathematics as one of their mandatory subjects. Topic shape and space are a crucial subject, and numerous mathematical education resources advocate for its inclusion at all levels. This topic provides students with opportunities to reason and trains them to think logically. Topic shape and space also useful for stating and solving problems in other areas of mathematics as well as in daily life. In practise, however, there are frequent failures in the mathematics curriculum, particularly in the topic of shape and space for primary school students. During the process of teaching and learning about this subject, they have a problem with either misunderstanding the concepts being taught or having incorrect assumptions about the subject. Therefore, methods and strategies for learning concepts that correspond to the maturity level of the students so that they can master the topic of shape and space with greater interest and enjoyment, while rejecting the notion that mathematical subjects are difficult and time-consuming.

A. Pyramid Holography

Holography, also known as holograms, is a modern imaging technology developed by physicists, chemists, mathematicians, and engineers [2]. Despite the fact that research into this technology has been ongoing since 1947, it is still in its early stages [3], [4]. Table 1 depicts examples of holographic techniques that don't require any special equipment and can be seen with the naked eye.

TABLE I
PAST STUDIES OF HOLOGRAM PYRAMIDS

Image	Description	Source
	Pepper's ghost is a 19th-century optical theatre effect used by illusionists.	The "Pepper's Ghost" effect [5]
	Using an invisible projection surface, Holographic Net can create the illusion of a video or image floating in mid-air.	Holographic Nets [6]
	The Holographic Spinning Mirror generates three-dimensional objects by displaying light from a high-speed video projector onto a system of mirrors and engines that are synchronised.	Holographic Spinning Mirror Technique [7]
	Transparent OLED screens - This transparent display screen is used to deliver dynamic or interactive content through a transparent surface that enables viewers to see both what is displayed on the skin and what is clearly visible behind the skin.	Transparent OLED Screen [8]
	This holographic pyramid utilises reflection in a manner similar to "Pepper's Ghost." The display of 3D objects is possible due to the 45-degree angle of the pyramid's sides in the glass, which creates the effect of a hologram reflected in it.	Holographic Pyramids [9]

There are numerous versions of floating image technology. Pepper's Ghost was one of the earliest holographic technologies developed. This technique was utilised in nineteenth-century cinema [5]. Pepper's Ghost is an optical illusion that John Henry Lada and Henry Dirks patented and popularised in 1863. (the year of the patent). John H. Pepper (1821 - 1900) was a Victorian-era performer and scientist renowned for his physics experiments that combined the worlds of science and theatre [10]. On December 24, 1862, Pepper and Dircks's "ghost" appeared on the art stage at the Royal Polytechnic Institution in a short playlet based on Charles Dickens's (1848) "The Haunted Man and the Ghost's Bargain" [11]. The Pepper's Ghost illusion is more complex than it appears; however, it is a simple lighting control with a supernatural effect. The illusion is created by placing the glass plane at a 45-degree angle to the viewer's viewing angle (Fig. 1).

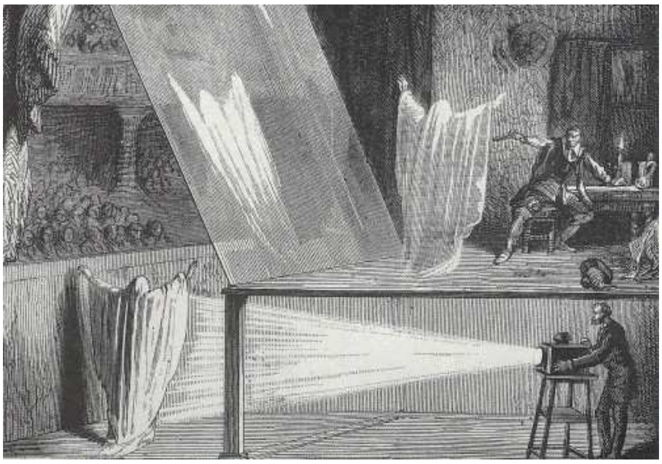


Fig. 1 An example of an original Pepper's Ghost illusion setup
Source: [12]

B. Pyramid Holography for Learning

Holographic pyramid is a floating image technology from a digital image display that is reflected on the surface of the pyramid [9]. The holographic pyramid setup method is simple and most popularly used for holographic presentations. The use of this technology requires an LCD screen, tablet, or mobile phone screen and a four-sided glass or acrylic pyramid. The image reflected through the screen appears inside the pyramid and appears to float in the air, separated from the physical display screen as shown in Fig.2. Through this hologram pyramid, users can obtain a realistic view of visual objects from all angles or positions of objects [13].

Holography is the next generation imaging technology. The global hologram market size in 2014 was approximately 18 billion and the global market is expected to reach 98 billion by 2025. It is expected to continue to grow at an average annual rate of around 14% in USD [14]. Education is one area where technology has a strong influence. Considering the increasing development of holographic technology, this technology has high potential to be used as a teaching and learning tool. Rose Khairunnisa and Azlina Ahmad [15] from Universiti Kebangsaan Malaysia have conducted a study on the use of 3D hologram pyramids and found that the hologram has a positive effect on students' visualization skills. Thus, holograms have the potential to be used in the classroom to complete visual materials that can be used for teaching and learning. Based on the results of Prihatmoko's study [16], learning with 3D objects through holographic pyramids can look interesting, fun, useful and innovative to advance future education, especially for primary school students.

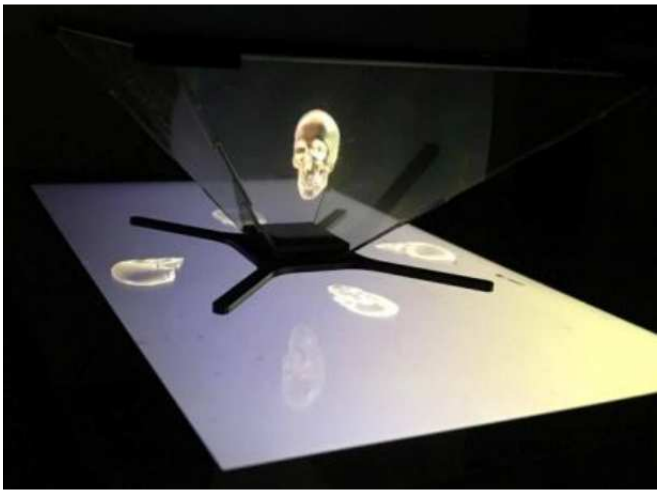


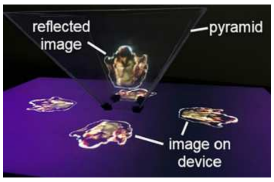
Fig. 2 3D Hologram Pyramid
Source: [17]

Based on educational arrangements, hologram pyramid studies have been conducted in subjects such as science, history and logistics. A 3D pyramid-shaped hologram (3DPH) study called HoloRead to improve reading and writing skills for preschool children was conducted by Barkhaya et al. [18]. 3DPH visualization tools emphasize the concept of learning while having fun using real 3D displays that guide students to anticipate and interpret learning objects from different perspectives.

According to a study by Arifudin et al. [19] in the field of science, holographic pyramids are used for teaching and learning about animal cells and plant cells. The study concludes that the use of 3D holographic presentations using holographic pyramids to educate and learn about animal and plant cells can boost the learning interest and comprehension of elementary school children. In addition, the holographic pyramid is an economical method for constructing holographic displays. Rosen & Nesic [20] have also investigated the usage of holographic pyramids in modern medical teaching. Rosen and Nesic claim that the impacts of holographic technology have significant promise for application in medical education and training. Their research revealed that nephrectomy specimens were exhibited in a holographic pyramid that gave students the impression that they were viewing living cells.

Holographic technology is used for interactive learning about dinosaurs from the Mesozoic Era, based on historical research. This research was carried out by Nugroho and Purwanto [21]. They believe that the usage of holographic 3D video helps and increases the students' interest in studying. In addition, the method of learning about dinosaurs becomes more engaging, efficient, and inventive. Orcos et al. [22] did 3D Visualization research utilising a holographic pyramid for the purpose of teaching the mathematical concepts of area and volume. Based on the findings of the study, it was determined that students enjoyed the optical impact of 3D holography and that the approach could draw their attention so that they would investigate the educational content more thoroughly. The application of holographic projection technology using hologram pyramids in the field of mathematics is not yet widespread. Additional study is required to evaluate the possible influence of holographic technology on elementary school children. Table 2 displays previous research on holographic pyramids.

TABLE III
PAST STUDIES OF HOLOGRAM PYRAMIDS

Image	Description	Source
	Architecture of Sino-Portuguese for History subject.	[23]
	Visual Spatial Skills for mathematics subject.	[24]
	Laryngectomy Specimen for Science subject.	[18]
	HoloRead for English subject.	[20]
	Dinosaurs – Mesozoic for History subject.	[21]
	Arabic e-learning for Arabic subject.	[25]

II. MATERIAL AND METHODS

The methodology used on effectiveness evaluation of holography display in the visual-electronic application for the topic space and shape involved summative evaluation.

A case study with eighty 80 primary school students from a school in Putrajaya and ten (10) experts was used to complete this evaluation. A task-based, semi-experimental method was used to measure the efficacy construct. All questionnaires, observation checklists, and sets of pre- and post-tests were made and tested for validity using Cronbach's alpha reliability coefficient. Fig. 3 shows the effectiveness evaluation model of the E-Visual MEL-VIS application prototype.

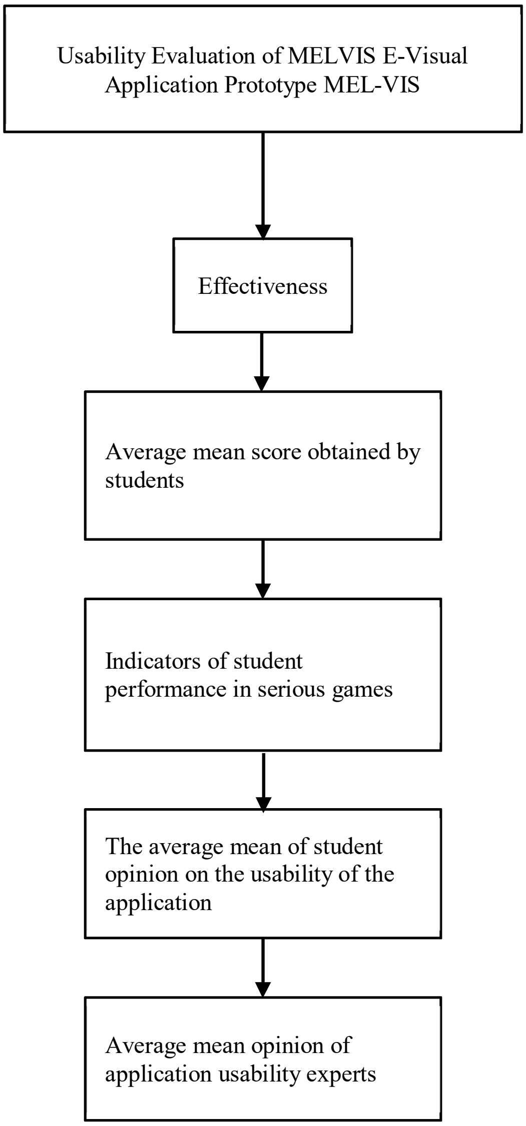


Fig. 3 E-Visual MEL-VIS Application Prototype Effectiveness Evaluation Model

III. RESULTS AND DISCUSSION

A. Construct Effectiveness – Pre-Test and Post-Test

The findings of the usability testing study are based on research question (i) which is: (i) Is visual electronic application developed using a holographic display based on multi-touch technology, effective in evaluating the effectiveness of its usability among primary school students in learning Mathematics? There are two (2) things that should be determined through the effectiveness construct, namely: (1) the success of MEL-VIS acting as a virtual teacher for Mathematics subjects and (2) the success of MEL-VIS as a teaching and learning tool by using the learning-while-playing approach through theme-based 'digital exploration' materials among primary school students to complete assignments through self-learning. Item (1) is implemented through a set of pre and post questions while item (2) uses a questionnaire instrument, based on the Effectiveness Construct Data Analysis Model: (i), (ECDAM-i) can be seen in Fig. 4.

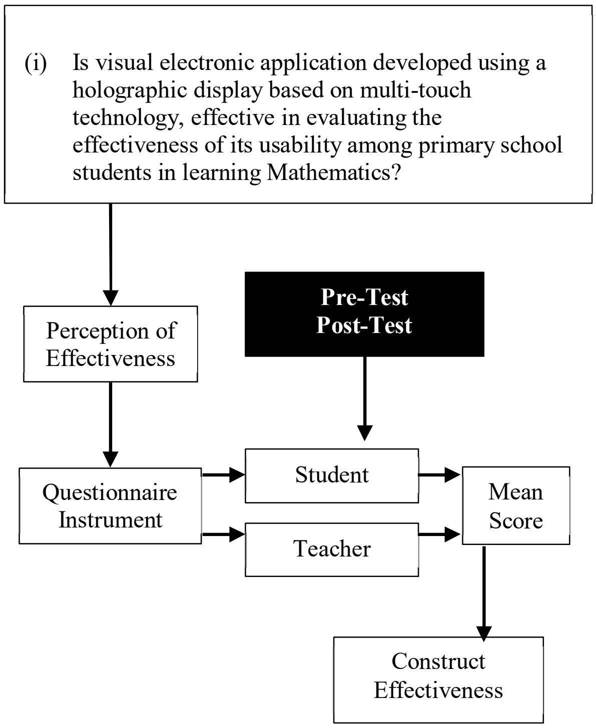


Fig. 4 Effectiveness Construct Data Analysis Model: (i), (ECDAM-i)

Exercises related to the topic of Shape and Space given to students in the pre-test and post-test are divided into three (3) categories, namely: (i) basic questions distinguishing 3D shapes, (ii) questions consisting of the characteristics of 3D shapes and (iii) questions related to 3D shapes in daily life. The exercises have almost the same questions and the same number of questions for the pre-test and the post-test. Following are the findings of the three (3) pre-test and post-test categories:

1) Category (i): Basic 3D Shapes: Table 3 displays the descriptive statistics of the Pre-Test and Post-Test for Category (i) Exercises. Pre-test category (i) basic questions distinguish 3D shapes, the minimum score is 0 and the maximum score is 100; while the post-test category (i) basic question distinguishing 3D shapes, the minimum score is 50 and the maximum score is 100. The mean of the pre-test category (i) is 58.35 and the mean of the post-test category (i) is 82.64. The mean of the post-category (i) test is higher than the pre-test category (i). From Table 2 it shows that there are 53 students out of 80 students who experienced an increase in the achievement of training skills category (i).

TABLE III
DESCRIPTIVE STATISTICS OF PRE-TEST AND POST-TEST FOR EXERCISES CATEGORY (I)

	N	**Mean**	**Standard Deviation**	**Min.**	**Max.**
Pre-Test Category (i)	80	58.35	21.685	0	100
Post-Test Category (i)	80	82.64	14.549	50	100

TABLE IV

PRE-TEST AND POST-TEST RANK FOR EXERCISES CATEGORY (I)

		N	Mean Rank	Sum of Ranks
Post-Test Category (i) – Pre-Test Category (i)	Negative Ranks	0[a]	.00	.00
	Positive Ranks	53[b]	27.00	1431.00
	Ties	27[c]		
	Total	80		

a. Post-Test Category (i) < Pre-Test Category (i)
b. Post-Test Category (i) > Pre-Test Category (i)
c. Post-Test Category (i) = Pre-Test Category (i)

TABLE V

PRE-TEST AND POST-TEST DESCRIPTIVE STATISTICS FOR EXERCISES CATEGORY (I)

	Post-Test Category (i) – Pre-Test Category (i)
Z	-6.370[b]
Asymp. Sig. (2-tailed)	.000

a. Wilcoxon Signed Ranks Test
b. Based on negative ranks.

Table 5, the Wilcoxon test shows that the median position of the Category (i) post-test (Mdn=67) is statistically higher than the median position of the pre-Category (i) test (Mdn=83), Z= -6.370, $p < 0.05$. Therefore, the test analysis shows that the student's skills have increased after using the E-Visual MEL-VIS application prototype.

2) Category (ii): Characteristics of 3D Shapes): Table 6 displays the descriptive statistics of the Pre-Test and Post-Test for Exercises Category (ii). The pre-test Exercises category (ii) questions consist of the characteristics of 3D shapes, the minimum score is 0 and the maximum score is 100 while the post-test category (ii) basic questions distinguish 3D shapes, the minimum score is 33 and the maximum score is 100. Mean of pre-test category (ii) is 54.15 and mean of post-test category (ii) is 81.30. The mean of the post-test category (ii) is higher than the mean of pre-test category (ii). Based on Table 7, it shows that there are 43 students out of 80 students who experienced an increase in the achievement of Exercises Category (ii).

Table 8, the Wilcoxon test shows that the median position of the post-test Category (ii) (Mdn=33) is statistically higher than the median position of the pre-test category (ii) (Mdn=67), Z= -5.802, $p < 0.05$. Therefore, the test analysis shows that the student's skills have increased after using the E-Visual MEL-VIS application prototype.

TABLE VI

DESCRIPTIVE STATISTICS OF PRE-TEST AND POST-TEST FOR EXERCISES CATEGORY (II)

	N	Mean	Standard Deviation	Min.	Max.
Pre-Test Category (ii)	80	54.15	35.0255	0	100
Post-Test Category (ii)	80	81.30	24.248	33	100

TABLE VII

PRE-TEST AND POST-TEST RANK FOR EXERCISES CATEGORY (II)

		N	Mean Rank	Sum of Ranks
Post-Test Category (ii) – Pre-Test Category (ii)	Negative Ranks	0[a]	.00	.00
	Positive Ranks	43[b]	22.00	946.00
	Ties	37[c]		
	Total	80		

a. Post-Test Category (ii) < Pre-Test Category (ii)
b. Post-Test Category (ii) > Pre-Test Category (ii)
c. Post-Test Category (ii) = Pre-Test Category (ii)

TABLE VIII

STATISTICAL TEST PRE-TEST AND POST-TEST FOR EXERCISES CATEGORY (II)

	Post-Test Category (ii) – Pre-Test Category (ii)
Z	-5.802b
Asymp. Sig. (2-tailed)	.000

a. Wilcoxon Signed Ranks Test
b. Based on negative ranks.

3) Post-Test Category (iii) – Pre-Test Category (iii): Table 9 shows the descriptive statistics of the Pre-Test and Post-Test for Exercises Category (iii). Pre-test Exercises Category (iii) questions related to 3D shapes in daily life, minimum score, and maximum score for post-test category (iii) and post-test category (iii) are 0 and 100 respectively. Mean of pre-test category (iii) is 40.36 and the mean of post-test category (iii) is 80.11. The mean of the post-test category (iii) is higher than the pre-test of category (iii). Based on Table 10, it shows that there are 67 students out of 80 students who experienced an increase in the achievement of Exercises category (iii).

TABLE IX

DESCRIPTIVE STATISTICS OF PRE-TEST AND POST-TEST FOR EXERCISES CATEGORY (II)

	N	Mean	Standard Deviation	Min.	Max.
Pre-Test Category (iii)	80	40.36	28.042	0	100
Post-Test Category (iii)	80	80.11	22.845	0	100

TABLE X

PRE-TEST AND POST-TEST RANK FOR EXERCISES CATEGORY (III)

		N	*Mean Rank*	*Sum of Ranks*
Post-Test Category (iii) – Pre-Test Category (iii)	Negative Ranks	1[a]	12.00	12.00
	Positive Ranks	67 [b]	34.84	2334.0 0
	Ties	12[c]		
	Total	80		

a. Post-Test Category (iii) < Pre-Test Category (iii)
b. Post-Test Category (iii) > Pre-Test Category (iii)
c. Post-Test Category (iii) = Pre-Test Category (iii)

TABLE XI
STATISTICAL TEST PRE-TEST AND POST-TEST FOR EXERCISES CATEGORY (III)

	Post-Test Category (iii) – Pre-Test Category (iii)
Z	-7.182[b]
Asymp. Sig. (2-tailed)	.000
a. Wilcoxon Signed Ranks Test	
b. Based on negative ranks.	

Table 11, the Wilcoxon test shows that the median position of the Category (iii) post-test (Mdn=33) is statistically higher than the median position of the pre-category (iii) test (Mdn=84), Z= -5.802, $p < 0.05$. Therefore, the test analysis shows that the students' skills have increased after using the E-Visual MEL-VIS application prototype. A comparison between the average mean scores obtained by each primary school student in the pre- and post-test shows a significant increase for students who use the prototype E-Visual MEL-VIS application as shown in Fig. 5. For the category (i) 3D basic shape; an increase of 24.29%, category (ii) 3D shape characteristics; an increase of 44.32%, and category (iii) 3D Shapes in daily life 39.75%. Overall, the increase in pre-test and post-test is 36.12%. Based on the use of MEL-VIS, the average student is able to get 80% or above for each training category given.

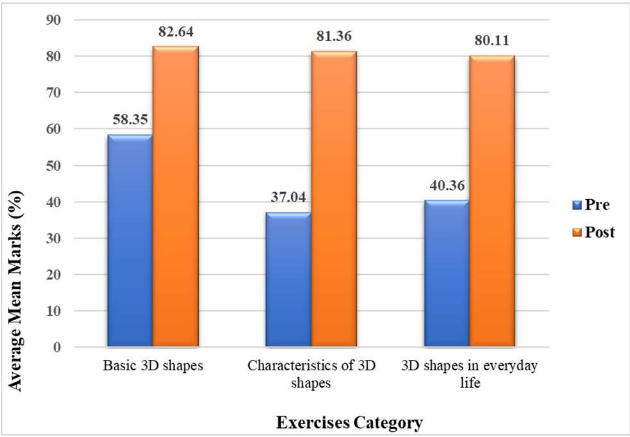


Fig. 5 The average achievement of the mean score of primary school students in Exercises

To refine the results of the study, an indicator of the performance of primary school students was developed as can be seen in Table 12. The average mean performance of each student in completing the assigned task is less than 1.5 as shown in Table 13. This shows that all primary school students can complete the tasks given without the help of teachers or classmates. This means that all students can master the topic of Shape and Space well after the learning is carried out by using the prototype E-Visual MEL-VIS application.

TABLE XII
PRIMARY SCHOOL STUDENT PERFORMANCE INDICATORS

Indicator	Performance	Explanation
1	Succeeded	Can answer without the help of a teacher or friend
2	Almost Failed	Need help from teachers and friends
3	Fail	Cannot answer questions

TABLE XIII
AVERAGE STUDENT MEAN IN COMPLETING THE ASSIGNMENT OF THE LET'S PLAY MODULE

	N	Min.	Max.	Mean	Standard Deviation
Modul Let's Play	80	1	3	1.25	.516
Valid N (listwise)	80				

B. *Construct Effectiveness – Levels of Effectiveness of Multi-Media Element Design (Multimedia-Fusion)*

This section explains the findings of the descriptive study for the seventh question, "Is the visual electronic application developed using a holographic display based on multi-touch technology effective in evaluating the effectiveness of its usability among primary school students for Mathematics?"

The application checklist instrument (ACI): MEL-VIS was built and used to study the level of effectiveness of the design of various media elements (multimedia fusion) in the prototype E-Visual MEL-VIS application. ACI: MEL-VIS was used to test the level of effectiveness of the design of various media elements (Multimedia-fusion) using descriptive analysis to explain the quantitative data analysed using the SPSS program. The findings of the study are described descriptively, by interpreting the mean score for each evaluation aspect; (interface, text, graphics, 2D & 3D, 2D & 3D Animation, Audio, Video, Interactivity, and Suitability). After using the E-Visual MEL-VIS application prototype, respondents responded to the statements given with the help of teachers and researchers to fill in the E-Visual application prototype checklist instrument: MELVIS (ACI: MEL-VIS). Respondents answered the instrument using a five (5) level Likert scale: (i) strongly disagree, (ii) disagree, (iii) neutral, (iv) agree, and (v) strongly agree as shown in Table 14 [26].

TABLE XIV
PRIMARY SCHOOL STUDENT PERFORMANCE INDICATORS

Description of Likert Scale	Likert scale	Likert scale range
Strongly disagree	1	1.00 – 1.80
Do not agree	2	1.81 – 2.60
Neutral	3	2.61 – 3.40
Agreed	4	3.41 – 4.20
Strongly Agree	5	4.21 – 5.00

TABLE XV
AVERAGE STUDENT MEAN IN COMPLETING THE ASSIGNMENT OF THE LET'S PLAY MODULE

	N	Min.	Max.	Mean	Standard Deviation
Interface	80	1.25	5.00	4.06	.916
Text	80	1.25	5.00	4.03	.979
Graphics (2D & 3D)	80	1.25	5.00	4.15	.894
Animation (2D & 3D)	80	1.00	5.00	4.15	.882
Audio	80	1.25	5.00	4.50	.688
Video (2D & 3D)	80	1.50	5.00	4.35	.778
Interactive	80	1.25	5.00	4.06	.916
Suitability	80	1.25	5.00	4.06	.916

To analyze the research findings of this section, using the mean score of all aspects of the E-Visual MEL-VIS prototype application was calculated. The method is interpreted as follows: Strongly disagree in the point range 1.00-1.80, Disagree 1.81-2.60, Neutral 2.61-3.40, Agree 3.41-4.20, Strongly Agree 4.21-5.00, see Table 14 [26]. Table 15 shows the level of assessment recorded by the teacher based on feedback from students. The aspects evaluated are interface, text, 2D graphics, animation, audio, video, interactivity, and suitability. Overall, the findings of the study show that the mean score for elements of various media (multimedia-fusion) is high, namely interface (M=4.06), text (M=4.03), graphics (M=4.15), animation (M=4.15), interactivity (M=4.06) and appropriateness (M=4.06). Only the audio (M=4.50) and video (M=4.35) elements got a very high rating (M=3.36). Overall, the data displayed in Table 15 shows that the design of various media elements (multimedia-fusion) is at a high level, which is an average mean of 4.17. This means, the prototype of the E-Visual MEL-VIS application receive positive response among primary school students.

C. Construct Effectiveness – Usability Level of MEL-VIS E-Visual Application Prototype

This section also explains the findings of the descriptive study for the research question (i), which is, "Is a visual electronic application developed using a holographic display based on multi-touch technology effective in evaluating the effectiveness of its usability among primary school students for Mathematics?" Descriptive analysis is also used to describe quantitative data by interpreting the mean score for each aspect of the evaluation of the E-Visual MEL-VIS application prototype. Ten (10) experts were used as respondents to respond to the statements provided in the usability checklist of the E-Visual application prototype: MELVIS for expert (ACIE: MEL-VIS). This is implemented by experts after trying to use the E-Visual MEL-VIS application prototype.

TABLE XVI
AVERAGE STUDENT MEAN IN COMPLETING THE ASSIGNMENT OF THE LET'S PLAY MODULE

	N	Min.	Max.	Mean	Standard Deviation
Learnability	10	3.20	5.00	4.42	.614
Effectiveness	10	3.20	5.00	4.24	.548
Ease of use	10	3.40	5.00	4.52	.559
Shape	10	3.50	5.00	4.53	.483
Help	10	4.00	5.00	4.70	.429
Satisfaction	10	3.50	5.00	4.25	.635
Learning Theory	10	3.60	5.00	4.56	.470
Interactive design of holographic displays	10	3.50	5.00	4.53	.483
Story Elements	10	3.60	5.00	4.64	.470

Table 16, shows the level of assessment recorded by the teacher based on student feedback. The aspects evaluated are based on the construct of reliability, effectiveness, ease of use, design and aesthetics, assistance, user satisfaction and storytelling. The interpretation method has used a five (5) level likert scale measurement which can be seen in Table 14. Overall, the findings show that the mean score for usability elements is high, namely learnability (M=4.42), effectiveness (M=4.24), ease of use (M=4.52), design (M=4.53), assistance (M=4.70) satisfaction users (M=4.25), learning theory (M=4.56), interactive design of holographic displays (M4.53) and storytelling elements (M=4.64). Overall, the data displayed in Table 16 shows the mean distribution of the usage list of the E-Visual MEL-VIS application prototype is at a high level which is an average mean of 4.48. This means, the prototype of the E-Visual MEL-VIS application receive positive response from experts.

IV. CONCLUSIONS

The effectiveness of the MEL-VIS application was evaluated using semi-experimental method, and the results were measured by comparing the results of a pre-test and a post-test. The survey was taken by a total of eighty (80) students who are currently enrolled in primary three (3) school. Both the experimental group and the control group were made up of the same group of students [27], [28]. Students are provided with practise papers as pre-tests. The amount and variety of the drill questions are nearly identical to those in the MEL-VIS application. The same group of students that comprised the experimental group administered a post-test three (3) months later.

The study found that the difference in average increase between the control and experimental groups for Training category (i) 3D basic shape increased by 24.29%, category (ii) 3D shape characteristics by 44.32%, and category (iii) 3D Shapes in everyday life by 39.75%. The average improvement from pre-test to post-test was 36.12%. This demonstrates that learning about 3D shapes with the E-Visual MEL-VIS application prototype is more effective than traditional methods. In addition, based on the MEL-VIS application checklist instrument (ACI: MEL-VIS), the effectiveness construct has a high mean value of 4.17. While, the average mean MEL-VIS application checklist instrument for expert (ACIE: MEL-VIS) is 4.48.

TABLE XVII
CRONBACH'S ALPHA COEFFICIENT GUIDE

Alfa Cronbach (α)	Description
$\alpha \geqslant 0.9$	Very Good
$0.8 \leqslant \alpha < 0.9$	Good
$0.7 \leqslant \alpha < 0.8$	Acceptable
$0.6 \leqslant \alpha < 0.7$	Questionable
$0.5 \leqslant \alpha < 0.6$	Weak
$\alpha < 0.5$	Unacceptable

This demonstrates that the prototype of the E-Visual MEL-VIS application was well received by elementary school students. The Cronbach alpha obtained from the pilot study of the both ACI: MEL-VIS and ACIE:MEL-VIS are high.

According to Pallant and DeVellis , the appropriate reliability coefficient should exceed 0.70 [29], [30]. George & Mallery [31] assign a reliability coefficient scale that is ⩾ 0.90 - very good, ⩾ 0.80 - good, ⩾ 0.70 - acceptable, ⩾ 0.60 - questionable, ⩾ 0.50 - weak, and ⩽ 0.50 - unacceptable. While Siswaningsih et al. [32] allocated a reliability coefficient scale as shown in Table 17.

Table 18 shows the results of the Cronbach's Alpha reliability test for the ACI:MEL-VIS. The ACI:MEL-VIS reliability test shows a reliability coefficient value in the range of 0.87-0.93 which is a high and good reliability value. Table 19 shows the results of the Cronbach's Alpha reliability test for the ACIE:MEL-VIS instrument. The test shows a reliability coefficient value between 0.84-0.90 which is a high and good reliability value. This demonstrates that both ACI: MEL-VIS and ACIE:MEL-VIS is highly reliable.

TABLE XVIII
ACI:MEL-VIS RELIABILITY TEST RESULTS

Category	Cronbach's alpha value	Description Cronbach's alpha value
Interface	0.88	Good
Text	0.93	Very Good
Images	0.91	Very Good
Animation	0.91	Very Good
Audio	0.87	Good
Interactive	0.89	Good

TABLE XIX
ACIE:MEL-VIS RELIABILITY TEST RESULTS

Category	Cronbach's alpha value	Description Cronbach's alpha value
Learnability	0.90	Very Good
Effectiveness	0.86	Good
Ease of use	0.87	Good
Shape	0.86	Good
Help	0.86	Good
Satisfaction	0.87	Good
Learning Theory	0.86	Good
Interactive design of holographic displays	0.84	Good
Story Elements	0.86	Good

REFERENCES

[1] M. Z. Zainuddin, "50,000 pelajar bakal terima peranti Cerdik pada akhir Mei 2021," no. April, Putrajaya, Apr. 14, 2021 [Online]. Available: https://www.bharian.com.my/berita/nasional/2021/04/810642/50000-pelajar-bakal-terima-peranti-cerdik-akhir-mei

[2] I. Vildan, "Classification of holograms and types of hologram used in holographic art," *Online J. Art Des.*, vol. 2, no. 3, pp. 15–26, 2014.

[3] P. C. J. Hill, "Dennis Gabor-Contributions to Communication Theory & Signal Processing," in *EUROCON 2007-The International Conference on" Computer as a Tool"*, 2007, pp. 2632–2637.

[4] R. A. Walker, "Holograms as Teaching Agents," *J. Phys. Conf. Ser.*, vol. 415, no. Isdh 2012, p. 012076, 2013, doi: 10.1088/1742-6596/415/1/012076.

[5] D. Rossi, "A hand-held 3D-printed box projector study for a souvenir from a mixed-reality experience," in *2015 Digital Heritage*, 2015, vol. 1, pp. 313–316.

[6] iDiA, "Holographic Net® Floating projection," 2014. [Online]. Available: http://www.idia.gr/net.html

[7] A. Jones, I. McDowall, H. Yamada, M. Bolas, and P. Debevec, "Rendering for an interactive 360 light field display," in *ACM SIGGRAPH 2007 papers*, 2007, pp. 40-es.

[8] Pro Display, "Transparent OLED Screen," 2020. [Online]. Available: https://prodisplay.com/products/transparent-oled-screen/. [Accessed: Mar. 20, 2022]

[9] T. Chehlarova and K. Chehlarova, "Managing Pepper's Ghost Illusion Using Intelligent Methods," in *2020 IEEE 10th International Conference on Intelligent Systems (IS)*, 2020, pp. 415–420.

[10] L. Kent, "Conjuring unseen forces: Rainmaking in Australia with John Henry Pepper," *J. Sci. Pop. Cult.*, vol. 2, no. 2, pp. 143–155, 2019.

[11] J. Brooker, "The polytechnic ghost: Pepper's ghost, metempsychosis and the magic lantern at the Royal Polytechnic Institution," *Early Pop. Vis. Cult.*, vol. 5, no. 2, pp. 189–206, 2007.

[12] M. Leeder, *The modern supernatural and the beginnings of cinema*. Springer, 2017.

[13] Haikuo Zhou, "The development, special traits and potential of holographic display technology," 2015.

[14] J.-H. Lim and J.-H. Chung, "A study on the Expressional Characteristics and Elements of Contents Using Hologram," *J. Digit. Converg.*, vol. 15, no. 4, pp. 405–411, 2017.

[15] R. K. Roslan and A. Ahmad, "3D Spatial Visualisation Skills Training Application for School Students Using Hologram Pyramid," *JOIV Int. J. Informatics Vis.*, vol. 1, no. 4, pp. 170–174, 2017.

[16] Y. Prihatmoko, "Student Perception About 3D Object from Hologram Pyramid for Learning," in *1st International Conference on Information Technology and Education (ICITE 2020)*, 2020, pp. 696–699.

[17] S. Q. M. Salih, P. S. Sulaiman, M. Ramlan, and R. Rahmat, "3D holographic rendering for medical images using manipulates lighting in a 3D pyramid display," *J. Adv. Sci. Eng. Res.*, vol. 7, no. 1, 2017.

[18] N. M. M. Barkhaya, N. D. A. Halim, and N. Yahaya, "Development of 3DPH: HoloRead for Preschool Children's Learning," in *Proceedings of the 2018 IEEE 10th International Conference on Engineering Education, ICEED 2018*, 2019, doi: 10.1109/ICEED.2018.8626977.

[19] A. Arifudin, D. Kuswandi, and Y. Soepriyanto, "Pengembangan Media Obyek 3 Dimensi Digital Sel Hewan dan Tumbuhan Memanfaatkan Piramida Hologram Untuk MTS," *J. Kaji. Teknol. Pendidik.*, vol. 2, no. 1, pp. 9–15, 2019.

[20] D. Rosen and O. Nesic, "A Novel Approach to Design 3D Models in Medical Education," *Medical Science Educator*, vol. 31, no. 2. 2021.

[21] A. Nugroho and A. Purwanto, "Pembangunan Media Pembelajaran InteraktiPembangunan Media Pembelajaran Interaktif menggunakan Video 3D Hologram di SMPN 25 Bandung (Studi Kasus Pembelajaran Dinosaurus Masa Mesozoikum)f menggunakan Video 3D Hologram di SMPN 25 Bandung (Studi Kasus Pembela," 2021.

[22] L. Orcos, C. Jordán, and A. Magreñán, "3D visualization through the hologram for the learning of area and volume concepts," *Mathematics*, vol. 7, no. 3, p. 247, 2019.

[23] K. Kalarat, "The use of 3D holographic pyramid for the visualization of Sino-Portuguese architecture," *J. Informatio N*, vol. 2, no. 5, pp. 18–24, 2017.

[24] R. Khairunnisa, "Aplikasi Teknologi Hologram Dalam Kemahiran Visualisasi Bagi Pelajar Sekolah Rendah," 2017.

[25] I. N. Hassan, N. C. Sitompul, and N. Nurjati, "Hologram Technology For E-Learning Arabic Language Pre-Primary And Primary School," *Akad. J. Teknol. Pendidik.*, vol. 10, no. 02, pp. 277–290, 2021.

[26] E. N. Nyutu, W. W. Cobern, and B. A. S. Pleasants, "Correlational Study of Student Perceptions of Their Undergraduate Laboratory Environment with Respect to Gender and Major.," *Int. J. Educ. Math. Sci. Technol.*, vol. 9, no. 1, pp. 83–102, 2021.

[27] E. I. Mansor, A. De Angeli, and O. De Bruijn, "The fantasy table," in *Proceedings of the 8th International Conference on Interaction Design and Children*, 2009, pp. 70–79.

[28] F. Wang, C. Gao, J. Kaufman, Y. Tong, and J. Chen, "Watching versus touching: The effectiveness of a touchscreen app to teach children to tell time," *Comput. Educ.*, vol. 160, p. 104021, 2021.

[29] P. Hibrid and P. Silat, "Sains Humanika The Hybrid Method Of Video And 360 ° Image In Silat Learning," vol. 3, pp. 31–40, 2019.

[30] M. S.N.M *et al.*, "Promoting student engagement by integrating new technology into tertiary education: The role of the iPad," *JOIV Int. J. Informatics Vis.*, vol. 4, no. 3, pp. 14–26, 2020, doi: 10.30630/joiv.4.3.404.

[31] D. George and P. Mallery, "SPSS for Windows Sep by Step: A Simple Guide and Reference, Boston, MA: Allyn & Bacon," *Obtenido https//www. Amaz. es/SPSS-Windows-Step-Simple-Reference/dp/0205375529*, 2003.

[32] W. Siswaningsih, H. Firman, and A. Khoirunnisa, "Development of two-tier diagnostic test pictorial-based for identifying high school students misconceptions on the mole concept," in *Journal of Physics: conference series*, 2017, vol. 812, no. 1, p. 12117.