Learning Effectiveness of 3D Hologram Animation on Primary School Learners

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Abstract. Integration of technology in education is changing traditional learning methods to satisfy global requirement towards Industrial Revolution (IR) 4.0. Innovative teaching methods help teachers to motivate and engage students in their learning. This study analyzed the application of three-dimensional hologram (3DH) technology for students in primary one, two and three, to find the learning effectiveness of 3D hologram technology in the classroom. Pre-test and post-test designs were adopted according to the primary school syllabus to collect data, which were analyzed statistically using the SPSS software. The results revealed that 3DH technology integration has a great effect that positively enhances the students' learning capacity and attracts their attention. As indicated, 72% of the students had better scores in the post-test compared to the pre-test examination after watching a 3DH animation. The increased scores prove that 3DH technology can positively influence and enhance the knowledge gained during the student learning process. An illustration in the form of a 3D hologram animation was able to grab the students' interest and capture their attention. This paper contributes to the field of education by looking at the adoption of 3DH technology, which could effectively enhance student learning quality at an early stage.

Keywords: *3D hologram animation; education; effective learning; integration technology; primary school.*

1 Introduction

Technology integration means the effective implementation of educational technology to inspire positive changes in teaching methods to facilitate students' learning and boost their capacity, productivity, and performance in their learning process. In Malaysia, Education 4.0 has been established, pushing the current education system towards the goals set by the government's new policy laid down in the Malaysia Education Blueprint 2013-2025. According to Fisk [1], this new vision on learning entails identifying sources of knowledge and motivating learners to learn the skills and knowledge they need. As for learning strategies, learners should be able to concentrate, which is one of the major factors in successful learning [2]. This is important especially for primary

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school children, as their attention span is limited and they easily get distracted [3].

In fact, children often struggle to stay focused during studying and easily get bored. This always happens in the learning process, as it is a part of growing up for them. In order to improve this, the adoption of effective learning technologies in education can help to attract children's attention and enhance their understanding when compared to traditional physical interfaces [4]. Based on Ahmad [5], 3DH technology can create a 3D-like illusion for the viewer towards audio, visual, and haptic content in order to explain a difficult concept or text by converting complicated information to a simpler form. These features are able to grab students' attention and allow them to observe and imagine the overall content as part of their learning process. Yet, 3DH is a new technology that is still in its developmental phase in the field of education. Thus, this study investigated the effectiveness of adopting 3DH technology for students in primary one, two and three in the classroom. Pre-test and post-test examinations were used to compare the scores in order to measure the students' understanding level. The key contribution of this empirical study is to give insight into students' and teachers' feedback towards the integration of 3DH technology in the learning environment and understand the key factors and possibilities in motivating and engaging students to improve their learning skills at primary school level.

2 Literature Review

2.1 Integrating Technology in Education

In education, the integration and effective use of technology in the teaching and learning environment is vital to enhance the learners' success. This can be defined as the effective implementation of technologies as an educational tool, equipment, or device, to help teachers and students to accomplish the intended learning outcomes [6]. The directive of technology integration in teaching and learning has led to a fundamental change in how teachers transfer knowledge and skills to learners.

Technology can play a supporting role, positively changing the way students learn, but it cannot be called a replacement for teachers. The teacher is the one who integrates the technology into instruction by encouraging and motivating students to grasp new knowledge in their studies. Teachers utilize technology as a tool to make instruction easier and foster more interest in learning on the part of the students [7]. Husain [8] emphasizes that the adoption of technology in education has a lot of advantages in terms of instructional methodology or delivery method in providing an effective learning environment for young

children. The study of Fernandez [9] found that students want to increase the use of technology in order to make learning 'more fun'. Children's motivation and concentration will increase when integrating technology with multiple intelligences into lessons.

2.2 Effective Learning for Children

Based on constructivist learning theory, rather than acquiring knowledge, learning is a process of constructing knowledge. Learners construct their own understanding and build new knowledge through contextual experiences [10]. Ambrose *et al*. [11] state that learning improves performance from experience, which is a process that leads to change related to the future. However, effective learning happens when classroom management creates a positive atmosphere in which students want to learn [12]. In other words, it is the effect of motivation that leads to the ability of children to concentrate and maintain their attention during the learning process. Effective learning utilizes teaching tools that help students eliminate distractions, boost focus, help concentration and increase productivity levels in their learning process. This is supported by Gilakjani [13], who reported that effective learning is motivated by the importance and value of the information presented in the learning environment.

In the perspective of psychology, the ability of children to focus and concentrate effectively is a critical first step and acts as a gateway to thinking toward learning. Many children are unable to maintain attention throughout long lessons in the classroom, especially primary school students. They easily get distracted by the smallest things, nodding off, sleeping and gazing when they feel the task given is boring [14]. Nevertheless, a child's attention span can be improved. As pointed out by Brooks-Gunn & Donahue [15], learning can benefit from technological media with educational content that are intended to be used to entertain rather than to teach. In this context, Fisch [16] explains that educational content integrated into technology media should be designed to have a narrative with an ongoing story made up from the educational message as the central content. If designed correctly, this can enhance childrens' comprehension, to guide their attention and subsequent learning.

2.3 3D Hologram (3DH) as a Teaching Tool

Generally, 3D hologram technology provides a 3D visualization tool, displayed using a photographic technique that records the coherent light of light beams and then represents the recorded image in a three-dimensional way [17]. Unlike a conventional film on a standard screen, a hologram displays products, objects, and animated sequences three-dimensionally, i.e. not actually 'there' but appearing to float completely freely in space [18].

3DH technology is recognized as an effective visualization tool and its application has large potential in the field of education. Ghuloum [19] states that 3DH technology is potentially an effective teaching tool that could reinforce the learning process in the future. According to the findings of Mnaathr & Basha [20], the application of 3DH technology in school can effectively increase learning ability and cognition in children. Their results pointed out that this technology allows to strengthen student motivation in learning via the use of model-based learning and visual effects. Sudeep [21] indicates that the way 3DH technology operates, creates an illusion of three-dimensional imagery that allows the student to view an object from many angles. This is much needed in terms of stimulating the imagination to give students a better understanding and enhance their motivation. Barkhaya & Halim [4] confirm that 3DH technology is able to improve children's cognitive learning skills and their concentration abilities.

3 Method

The aim of this research was to carry out a feasibility study of integrating three-dimensional hologram (3DH) technology in primary school by examining its effectiveness in enhancing children's learning in the classroom. A total of 50 students from SJK Chung Hua Kranji Bau, Sarawak participated in the evaluation. The participants were grouped into 3 age categories: primary one (7 years old), primary two (8 years old) and primary three (9 years old) students.

A mixed qualitative and quantitative method was used in this research. A quantitative method was designed according to the pre-test and post-test questionnaires research model. A qualitative method was used through classroom observations and interviews with teachers. In planning the pre-test and post-test questionnaires, previous examination papers on the topic of 'Plant Growth' were taken as the reference to formulate the questions. The questions were designed according to the school syllabus guidelines and included various types of questions, such as fill in the blanks, multiple choice and matching the correct answers. The dependent variables were based on teaching and learning taxonomy when designing the pre-test and post-test questions. It was crucial to measure the development of the students': (a) knowledge, (b) understanding, (c) memory, and (d) response on the topic. However, one independent variable was also included in this study, i.e. the preference for teaching modes of the students: conventional teaching mode or 3D hologram animation. The pre-test questionnaire was aimed at finding the students' learning experience with the conventional teaching mode. The post-test questionnaire was aimed at finding the students' opinions on the adaption of a 3D hologram animation for teaching the subject. In addition, the questions for the topic of 'Plant Growth' in both the pre-test and the post-test were the same, but presented in a different sequence.

This was important in order to make sure that all the questions in the evaluation form were reliable and the objective would be achieved when testing the comprehension levels of the students after watching the 3D hologram animation. The data collected from both tests were compared and analyzed statistically using the SPSS software.

Furthermore, informal observations were also important to capture the experiences of the students as they watched the 3DH animation in the classroom. Two cameras were used to record the interaction. One camera took photos while the other one was used to record video to observe the childrens' behavior and reactions. Apart from that, teachers were interviewed during this phase in order to collect as much information as possible on the application of 3DH technology as a learning material in the classroom.

Technically, two types of devices were installed in the classroom, consisting of a fan type hologram and a pyramid projector hologram. The 3D holographic fan is a device that is imaged by rotation (Figure 1). However, this type of hologram device is unable to produce sound. Therefore, an external audio device consisting of a Bluetooth speaker is needed to project the sound, playing at the same time together with the hologram animation from the fan device. On the other hand, the pyramid projector hologram device works on the principle of Pepper's ghost (Figure 2) so that the video appears to hover in mid-air. This principle creates a 3D-like illusion for the viewer. The audio of animation from this device comes from a TV set installed in the pyramid projector. Both devices were compared to see which one is more suitable in terms of creating interest among the students as well as in terms of application in education for primary school children.

A three-minute 3D animation hologram was developed for this study on the topic of 'Plant Growth' and designed according to the primary school syllabus for science subjects. The animation was created in two different languages, Mandarin and English, to be used as a medium of teaching using 3DH animation (Figure 3).

The overall process of the research was primarily divided into three phases: pre-test; 3D hologram animation showcase; and post-test. In the first phase, the participants' characteristics and their knowledge in learning the topic of 'Plant Growth' were evaluated with the pre-test survey (Figure 4). Next, the three-minute 3D animation hologram was shown to the participants on the topic of 'Plant Growth' (Figure 5). In the last phase, the post-test questionnaire for the topic of 'Plant Growth' was distributed to the students to examine their understanding after watching the 3D animation hologram (Figure 6). Sample photos were taken during the research process, as shown in Figures 1-6:

Figure 1 Fan hologram device used for showing 3D animation.

Figure 2 Pyramid projector hologram device used for showing 3D animation.

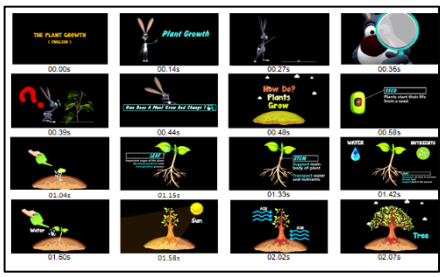

Figure 3 A 3-minute 3D animation hologram shown to participants on the topic of 'Plant Growth'.

Figure 4 Instruction given to the students to fill out the pre-test questionnaire.

Figure 5 3D Hologram animation being presented to the students. They are very excited to watch it.

Figure 6 Students answer the questionnaire with confidence after watching the 3D hologram animation.

The scores from the pre-test and post-test examination were then analyzed statistically using the SPSS software. In the meantime, classroom observation was conducted and most of the teachers were interviewed to obtain their feedback on the possibility of application 3D hologram in the classroom.

4 Findings

Table 1 shows a descriptive analysis of the demographic data for the 50 students in the evaluation.

Table 1 Participants' demographic profile.

Demographic Characteristics		Frequency	Valid (%)
Gender	Male	27	54%
	Female	23	46%
	Total	**50**	**100%**
Ethnicity	Malay	18	36%
	Chinese	19	38%
	Iban & Bidayuh	13	26%
	Total	**50**	**100%**
Age and education	7 years old (Primary 1)	20	40%
	8 years old (Primary 2)	15	30%
	9 years old (Primary 3)	15	30%
	Total	**50**	**100%**

The analysis of the participants' gender revealed that more than half (54%) of the participants were male and 46% were female. Most of the participants were ethnic Chinese, accounting for 38%, followed by Malay (36%), Iban and Bidayuh (26%). As for the participants' education level, they were mostly primary 1 students (40%), 15 participants (30%) were from primary 2, and 15 participants (30%) were from primary 3 students. In order to determine the effectiveness of learning based on 3D hologram technology, a comparison of the pre-test and post-test achievements was conducted, of which the results are shown in Table 2.

Table 2 Comparison of pre-test and post-test achievements.

Group	Mean Score Pre-Test (%)	Mean Score Post-Test (%)	Different
Primary 1 (n=20)	71.55	85.00	13.45
Primary 2 (n=15)	71.66	79.58	7.92
Primary 3 (n=15)	71.25	82.08	10.83

Comparison of the pre-test and the post-test results indicated that the students had increased their understanding of the information available through learning based on the 3D hologram animation. As a result, primary 1 students obtained a mean score of 85% correct answers in the post test, i.e. an increase of 13.45% correct answers compared to the 71.55% pre-test score. There was an increase of 7.92% in the score from the group of primary 2 students between the pre-test (71.66%) and the post-test (79.58%). Meanwhile, the primary 3 students obtained a mean score of 82.08% correct answers in the post-test, i.e. an increase of 10.83% compared to the 71.25% the pre-test score. To sum up, in total 72% of the students had better scores in the post-test compared to the pre-test after watching the 3DH animation. Based on the analysis, the improvement

of the mean achievement scores proves that the use of a 3D hologram animation had a positive effect, led to an increase in knowledge, motivation, and learning achievement levels for the primary school learners.

In the next stage, the paired sample t-test method was used to quantitatively measure the students' mean achievement scores, evaluated before and after the use of the 3D hologram animation in the classroom. The results of this test are shown in Table 3.

Table 3 SPSS results of pre-test and post-test for mean achievement scores.

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	POST_TEST - PRE_TEST	11	16.345	2.312	6.355	15.645	4.759	49	.000

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	POST-TEST	82.5	50	12.24	1.731
	PRE-TEST	71.5	50	16.57	2.343

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	POST_TEST & PRE_TEST	50	.388	.005

Table 3 shows that the scores of the students in the post-test had increased. According to the analysis, the improvement in the mean achievement scores from the paired sample t-test revealed that there was a significant positive correlation ($r = .388$). Based on these findings, it can be said that the 3D hologram learning materials had a positive impact on the students in terms of increasing their achievement levels. The paired samples correlation table also shows strong evidence ($t = 4.759$, $p = 0.000$, $p < 0.005$) that teaching by using the 3D hologram effectively enhanced student learning. The results were proved by the improved scores in the post-test after watching the 3D hologram animation. In this data set, the overall average of the scores was improved by approximately 11 points with a 95% confidence interval ranging from 6.35 to 15.65. The eta squared statistic of $0.32 > 0.14$ [4.7592/4.7592 + (49-1)] indicated that this a large effect, based on [22].

5 Discussion

Overall, 3D hologram technology has the potential to be used in the teaching-learning process for primary school children, as it can provide an innovative virtual teaching environment, offering knowledge that can be transferred and

applied to real-life situations. The effectiveness of 3D holograms is apparent from the students' increased motivation. It was observed that the 3D hologram's visual effect was able to grab the students' interest and attract their attention. This was proved when the students noticed the mistakes they made in the pre-test after watching the 3D hologram animation. The students were requested to fill out another test and they were confident to answer the questions correctly.

The students were interested in this kind of learning method compared to conventional teaching approaches. They enjoyed it and requested to have this kind of technology as a learning method in the school. Likewise, all the teachers were also excited about the 3D hologram technology. The interviews showed that this technology is beneficial for numerous reasons, one being the increased attention span of the children in learning.

However, the study also showed that the 3D effect of the fan type hologram device is more suitable to be applied in the classroom compared to the pyramid projector hologram. According to the feedback from both teachers and students, the visual effect of the fan type hologram device is more attractive compared to that of the pyramid projector hologram. The fan type hologram is also able to save space and is easy to install in the classroom. The fan type hologram device still has the potential of being further improved in the future, such as integrating the input of the sound system. The sound of the hologram projector plays an important role in grabbing the students' attention in their learning process. Therefore, it needs to be implemented in the hologram projector device in order to make the device more advanced, convenient and useful.

Despite this, the study also encountered challenges with data collection. Some students, especially the primary one children, were unable to focus on the task and did not follow the instructions given because they immediately started to read and write. Consequently, they failed to read certain text from the questionnaires and failed to write down some of the answers to the questions. In order to collect data from young children, one-on-one interviews and teacher guidance were needed to fill out the questionnaires according to their answers. Therefore, it took more time than expected to finish a session. Yet, the students still enjoyed the learning process through watching 3DH technology in the classroom.

Aside from the obvious benefit of engagement, 3DH technology as a learning tool should be designed not simply to present information, but also to guide the learner's cognitive processing during learning. Even so, not all subjects are applicable for use with 3DH technology as teaching material. Ideally, the use of 3D hologram vision is suitable for subject content that requires visual aids to convey the message, such as historical subjects, science subjects, astronomical

phenomena, the structure and developmental process of humans, animals and plants. Due to the limitations of their thinking abilities, young children cannot comprehend higher scientific notions [23].

6 Conclusion

To conclude, this research presents the application of three-dimensional hologram (3DH) technology in the classroom and examined its effectiveness for student learning in primary one, two and three. According to the achievement test findings, 3DH could effectively improve students' learning outcomes and their achievement level. This was proved by the 3DH animation successfully drawing the students' attention and enhancing their understanding. The findings clearly indicate that this technology helps achieve a sense of reality that is motivating for young children. This should not be overlooked, as motivation in itself is an important aspect of learning. For educators, 3DH technology is a gateway to make a connection between the technological revolution of Industry 4.0 and the new Education 4.0 framework.

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