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Exploring the Student's Interaction with Augmented Reality and Their Relationship to Learning Achievement

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Abstract:
Augmented Reality (AR) is one of the latest technology that has grown significantly due to its effectiveness in various fields includein education field. AR can be defined as a technology where virtual object can be overlaid into real environment in real time. AR can serve as an effective tool to ensure the learning process more attractive and engage the student. However, previous studies on AR have not provided an in-depth investigation of the learning process, especially the interaction involved in student while they use an AR. Therefore, this study aimed to determine the student interaction and their performance in subject content, and their relationship between them while using AR. A quantitative research design was employed with 34 grade 5 elementary school students as respondents. The results of the content analysis towards student interaction with the AR demonstrates that turning the AR markers, inspecting the AR elements and commenting on the AR elements are recorded as the highest number of interactions compared to others. Results from a Spearman correlation analysis show that there are six interactions that have significant correlations with achievement in science among the students with the correlation direction of each relationship is positive.

Keywords: *augmented reality, interaction, mixed reality*

1. INTRODUCTION

The presence of technology in education has lasted for a decade. The practice has been adopted for a long time in line with the development of technology. Due to the new technologies, educational tool has reforms the way of the education system evolved. As the landscape of education has change across age and with the adoption of Industrial Revolution 4.0 (IR 4.0) has bring a new paradigm in education. The IR 4.0 has emphasized on four components and one of the fourth component is the integration of latest technology in education. One of most the promising digital technology that involve combination of sound, sight and touch is Augmented Reality (AR). AR can bring new learning environment, raising theengagement and motivation of student in class as well as increase the learningexperience.AR is powerful and type of interactive technology that combine virtual and real world and engages people with digital content (Fenu &Pittarello, 2018). Many studies reported the

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beneficial effect of AR in many different level of learners in the matter of student's motivation, engagement, enjoyment and learning attitude (Ibáñez & Delgado-Kloos, 2018).

However, studies regarding to AR in education mostly were performed in higher education settings (Bacca et al., 2014). Therefore, the target group such as primary school students should be investigated on AR in education in future. Although many research studies have shown that AR have a positive impact and popular among educational contexts of application, there are numerous matters waiting to be discovered. Despite this, the issues of interaction or learning processes of the students while using AR technology are rarely discussed (Bacca et al., 2014; Cheng et. al, 2019)and still not well understood. There are a few studies attempt to explore the student's interaction with AR but for different settings and purpose like interaction of visitors for painting appreciation using AR(Chang et al.,2014), child-parent interaction with AR (Cheng & Tsai, 2014; Cheng & Tsai, 2016) and collaborative behavioral pattern with mobile AR among undergraduate students (Lin, et al., 2013). Yet we lack of an in depth exploration of AR interaction among primary school students. The interaction portrayed by the students facilitate us to understand the behavior depth and lead educational practitioner to strategize the right instructional strategies to be used in learning environments (Hou & Wu, 2011). Furthermore, only a few studies explore the knowledge construction processes in AR application (Bacca et al., 2014). From this perspective, we also examine student's learning achievement while interacting with AR. Therefore, this study aimed to determine the primary school student interaction and their achievement in subject content, and their relationship between them while using AR.

2. METHODOLOGY

2.1 Research Design

In this study, a quantitative approach was adopted where the interaction of student with AR and learning achievement were examined by quantitative methods.

2.2 Sample

The sampling technique used in this study was convenience sampling method because the selection was based on accessible school. The students that involved in this study were selected by the teachers. In total, 34 students (32% male, 68% female) from one of the 5th grade primary school in East Malaysia involved in this study. In term of experience, the students are less knowledge on augmented reality.

2.3 AR Application

In this study, an AR educational book was developed to help students learn about science concepts. The 3D virtual objects were prepared using an Autodesk Maya and the AR platform was developed using Unity 3D. This application looks like a normal educational book, but there are AR markers were incorporated in the interface. The only requirement to run this system were basic equipment such as a laptop/desktop, AR markers and a webcam/camera to view and render all multimedia virtual objects such as 3D virtual objects. The selected subject unit was"Investigating the Earth and the Universe" unit of a primary school science course because the content requires a high imaginative ability where AR could visualizing abstract science concepts.

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2.4 Research Process

The consent or permission from Educational Minister and the involved school has been applied in this study. Once the ethics permission has been approved, the researcher can begin the research activities. The settings of this study was conducted in the school laboratory which equipped with personal computers and web cameras. Before implementation, students were briefly explained on how to use AR to avoid confusion. Then, each student was required to freely read and use AR with their partner. Researchers adopted a student-centered approach where students are divided into groups of two and learn in AR environment on their own. The students were expected to reach the conclusion on their own on their interaction with the AR. All activity and interaction among students and their behavior while operating AR was videotaped for further exploring and analyzing their interaction. After AR implementation, each student was required to sat for the test to acquire the conceptions after the AR treatment given.

2.5 Data collection tool

To reveal the observed interactions of student while using AR, the coding scheme developed by Cheng and Tsai (2014) was used. For this study, only related major interaction were selected that consist of several specific behaviors as shown in Table 1. For learning achievement test, it was constructed to measure students' understandings of science concepts. The test consists of multiple choice items, drawing and labelling and structured questions. The questions in the test were referred to the textbooks and teaching materials and validated by the two subject matters expert with more than 5 years of experience in teaching science course.

Table 1. Coding scheme

Main Behavior	Specific Behavior	Code	Description
Behavior of student's reading	Reading	c1	The student read the AR book
	Pointing	c2	The student point at the details of pictures or the content of the in AR
	Commenting	c3	The student makes comments on the pictures or the content of the AR
	Questioning	c4	The student ask questions on the pictures or the content of the AR
Behavior of student's interaction with the book's content	Responding	c5	The student respond to the questions or comments on the AR
	Repeating	c6	The student repeats the additional information regarding the pictures or the content of the AR ..
Children's interactionoriented behaviors regarding the AR elements	Pointing (AR)	ca2	The student point at the details of the AR elements
	Commenting (AR)	ca3	The student makes comment at the details of the AR elements
	Questioning (AR)	ca4	The student ask question about the details of the AR elements
	Responding (AR)	ca5	The student respond to the questions or comments on the AR elements
	Repeating (AR)	ca6	The student repeats the additional information regarding the AR elements
Children's behaviors of operating AR	Controlling	ca7	The student controls the operation of the AR
	Turning	ca8	The student turn the markers/AR to view different perspective of the AR elements
	Inspecting	ca9	The student inspects the AR elements and tries to touch it.
	Intervening	ca10	The student intervenes in the operation of the AR
Others	Distraction	ca11	The students is distracted during the process of reading

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Figure 1. Some photos of student's interaction with AR

2.5 Data analyses

The recorded video was analyzed using content analysis approach. Each observed interaction was reviewed, noted in the form, chronologically coded according to the specific behavior and was counted from video records. Then the frequency, percentages and standard deviations were analyzed descriptively. For learning achievement test was analyzed by descriptive method (minimum, maximum, mean and standard deviation). Then the correlation test was performed to discover the relationships between their interactions and achievement in learning. Spearman Correlation test was used due to the abnormal distribution of data. And for this study, the value of inter-rater reliability was obtained by the percentage of agreements between the researchers and another research assistant which involved in the coding for interaction was 80 percent for AR student interaction with Cohen's kappa value obtained equal to 0.869 where this value was considered as satisfactory.

3. RESULTS AND DISCUSSION

3.1 Student's interaction while using AR

The data obtained were recorded in atable according to the main behavior and followed by the specific behavior of the students while using AR. Table 2 shows the findings of student's interaction while using AR which consists of all codes and their percentages. In total, there are 3712 interactions were counted.

Table 2. Frequency of codes for their interaction

Main Behavior	Specific Behavior	Code	Frequency	Percentage
Behavior of student's reading	Reading	c1	289	7.8
	Pointing	c2	159	4.3
	Commenting	c3	289	7.8
Behavior of student's interaction with the book's content	Questioning	c4	61	1.6
	Responding	c5	81	2.2
	Repeating	c6	9	0.2
Children's interaction-oriented behaviors regarding the AR elements	Pointing (AR)	ca2	290	7.8
	Commenting (AR)	ca3	435	11.7
	Questioning (AR)	ca4	115	3.1
	Responding (AR)	ca5	225	6
	Repeating (AR)	ca6	6	0.2
Children's behaviors of operating AR-	Controlling	ca7	424	11.4
	Turning	ca8	613	16.5
	Inspecting	ca9	598	16.1
	Intervening	ca10	47	1.3
Others	Distraction	ca11	71	2
Total			**3712**	**100**

Through the quantitative content analysis, it was revealed that the ca8 category, which is turning the AR marker to view different perspective of AR element was the most frequent interactions (ca8, frequency = 613, 16.5%). In addition, the students also frequently inspecting AR element and likely try touch it (ca9, frequency = 598, 16.1%). The findings also indicate that the students prefer to make comments on the AR elements (ca3, frequency = 435, 11.7%) and control the operation of AR (ca7, frequency = 424, 11.4%). Examination of the coded interaction also shows that student likely to read the content in the AR and makes comments on the content in the book with both interaction shows the same number of frequency (ca1, c3, frequency = 289, 7.8%). Similarly, the student also prefers to point at the details of the AR elements that generated on the screen (ca2, frequency = 290, 7.8%). The students also were likely to responds to the questions or comments on the AR elements (ca5, frequency = 225, 6%) and pointing at the details of the pictures of the AR-based book (c2, frequency = 159, 4.3%). While the least interaction occurred in this study is the c6 and ca6 categories which were repeating the additional information of friends regarding the pictures or content in the books (c6, frequency = 9, 0.2%) and on the AR elements (ca6, frequency = 6, 0.2%). For interaction that's not associate with learning activity, it was revealed that the students also try to interrupt their friends' operation of AR (ca10, frequency = 47, 1.3%) and were distracted while using AR-based book (ca11, frequency = 71, 2%).

In contrast to the findings obtained in the study of Cheng and Tsai (2014), which shows that the most dominant interaction indicated by the respondent is reading AR books, followed by controlling AR, rotating the device to view virtual objects from different angles, respond to friend queries about the contents of the book and comment on AR elements. While in Yilmaz's (2016) study, the finding shows that the respondents in their study revealed that the interaction of pointing to the details of AR elements as the most dominant interaction followed by respond to friend's questions about AR elements, inspect element of AR, turning AR marker and control AR operation. In this study, the findings show that throughout the duration of the learning session, turning the AR book or AR markers to view the digital contents from different perspectives is the most dominant interaction. This finding may be due to the content of the study is about investigating the earth and the universe that required spatial visualization capabilities. Therefore, to see the movement or rotation of the earth, the moon and the sun, it is easier if the students can observe the movement from various views to enhance their understanding.

3.2 Student's learning achievement

Learning achievement was measure using a performance test after they using AR. The full mark for the test is 100 marks. Table 3 shows the descriptive analysis of the test data which consisted of minimum, maximum, mean and standard deviation. Based on the test, it was shown that the minimum mark for the test is 60.8 while the maximum mark is 100. The mean and standard deviation for the test is 77.709 and 8.886 respectively.

Table 3. Descriptive analysis for test score (N=34)

	N	Minimum	Maximum	Mean	Standard deviation
Test	34	60.8	100	77.709	8.8861

3.3 The relationship between student's interaction and learning achievement

In this study, the relationships between student's interaction and learning achievement were determined through Spearman correlation analyses and results are illustrated in Table 4. The findings show that the interaction of reading the AR book (r = .809, $p< 0.05$), pointing to AR element and try to touch it (r = .754, $p< 0.05$), commenting to AR element (r = .785, $p< 0.05$), controlling the AR (r = .652, $p< 0.05$), turning the AR to view different angles of the AR elements (r = .500, $p< 0.05$), and inspecting the AR elements (r = .782, $p< 0.05$) were among the interaction that show a positive correlation to the learning achievement.

Table 4. The correlation between interaction and learning achievement

Interaction	Learning Achievement
Read	.809**
Pointing	.208
Commenting	-.145
Asking	-.228
Answering	-.033
Repeating	-.170
Pointing (AR)	.754**
Commenting (AR)	.785**
Questioning (AR)	.325
Responding (AR)	.325
Repeating (AR)	-.143
Controlling	.652**
Turning	.500**
Inspecting	.782**

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

The correlation findings show that interactions such as reading shows a positive relationship to achievement in science. This may be due to the use of AR developed in the form of books. Physical forms of the book still play a major role in the field of education around the world. The textbook is said to be readable and has been used for many years.Additionally, the findings also show that inspecting the AR elements and trying to touch them has relationships with achievements in science. This finding is in line with the study conducted by Cheng and Tsai (2014). The students prefer to use AR as there are 3D objects appearing on paper or note book used in the study. Creating 3D objects makes aphysically book interesting and gives a real and magical feeling. In addition, the interactions controlling the operation of AR and turning the AR markers show high frequencies and have relationships with achievements in science. User controls in AR can help students learnspatial content. The developed AR allows students to view virtual objects easily by simply moving the AR marker to change the perspective. This isbecause when students interact with learning content throughAR, they have more control over how the information is communicated.AR allows students to have

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control over how they areexamine the content that leads to an increase in learning.

4. CONCLUSION

The increasingly of AR popularity has taken effect in educational research in the last decade. However, only limited studies that explore the AR related learning, especially which involve the interaction of students and AR. The goal of this study is to reveal the interaction of the student while they interacting with the AR. The results revealed that the dominant interaction shown by the student while using AR is turning the AR followed by inspecting the AR elements. The interaction and learning achievement relationship analyses also showed us that there are some of the interaction that we should emphasized while using AR. This study has gone some way towards the enhancing our understanding towards enhancing our understanding of the interaction of student when engaging with AR. However, this study requires further exploration. Further research might explore the relationship between student's interaction and their achievement in the learning content which involve student with different learning style.

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6. REFERENCES

[1] Bacca, J., Baldiris, S., Fabregat, R., & Graf, S. (2014). Augmented reality trends in education: a systematic review of research and applications

[2] Cheng, K. H., & Tsai, C. C. (2014). Children and parents' reading of an augmented reality picture book: Analyses of behavioral patterns and cognitive attainment. Computers & Education, 72, 302-312.

[3] Cheng, Y. W., Wang, Y., Cheng, I. L., & Chen, N. S. (2019). An in-depth analysis of the interaction transitions in a collaborative Augmented Reality-based mathematic game. Interactive Learning Environments, 1-15.

[4] Fallavollita, P., & Navab, N. (2018). Augmented Reality in Aging and Medical Education. In Mixed and Augmented Reality in Medicine (pp. 127-134). CRC Press.

[5] Fenu, C., & Pittarello, F. (2018). Svevo tour: The design and the experimentation of an augmented reality application for engaging visitors of a literary museum. International Journal of Human-Computer Studies, 114, 20-35.

[6] Hou, H. T., & Wu, S. Y. (2011). Analyzing the social knowledge construction behavioral patterns of an online synchronous collaborative discussion instructional activity using an instant messaging tool: a case study. Computers & Education, 57(2), 1459-1468.

[7] Ibáñez, M. B., & Delgado-Kloos, C. (2018). Augmented reality for STEM learning: A systematic review. Computers & Education, 123, 109-123.

[8] Ismail MI, Arshah RB. (2016). The Impacts Of Social Networking Sites In Higher Learning. International Journal of Software Engineering and Computer Systems, 2(1), 114-9

[9] Palmarini, R., Erkoyuncu, J. A., Roy, R., & Torabmostaedi, H. (2018). A systematic review of augmented reality applications in maintenance. Robotics and Computer-Integrated Manufacturing, 49, 215-228.

[10] Phon, D. N. E., Ali, M. B., & Halim, N. D. A. (2015). Learning with augmented reality: Effects toward student with different spatial abilities. Advanced Science Letters, 21(7), 2200-2204.

[11] Phon, D. N. E., Rahman, M. H. A., Utama, N. I., Ali, M. B., Halim, N. D. A., & Kasim, S. (2019). The Effect of Augmented Reality on Spatial Visualization Ability of Elementary School Student. International Journal on Advanced Science, Engineering and Information Technology, 9(2), 624-629.

[12] Yilmaz, R. M. (2016). Educational magic toys developed with augmented reality technology for early childhood education. Computers in Human Behavior, 54, 240-248.