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การพัฒนาชุดการสอนแบบความเข้มข้นจริง เสริมในการเรียนโดยใช้สถานการณ์จำลองด้วยการเรียนรู้จาก การจัดการกระทำ เพื่อส่งเสริมความสามารถในการคิดวิเคราะห์ของนักเรียนระดับชั้นมัธยมศึกษาตอนต้น

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# การพัฒนาชุดการสอนแบบความเป็นจริงเสริมในการเรียนโดยใช้สถานการณ์จำลองด้วยการเรียนรู้จากการจัดกระทำเพื่อส่งเสริมความสามารถในการคิดวิเคราะห์ของนักเรียนระดับชั้นมัธยมศึกษาตอนต้น

## Development of an AR Instructional Package in Simulation Method with Manipulative Learning to Enhance Analytical Thinking Ability of Lower Secondary School Students

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### บทคัดย่อ

การวิจัยนี้มีวัตถุประสงค์เพื่อออกแบบและพัฒนาชุดการสอนแบบความเป็นจริงเสริมในการเรียนโดยใช้สถานการณ์จำลองด้วยการเรียนรู้จากการจัดกระทำเพื่อส่งเสริมความสามารถในการคิดวิเคราะห์ของนักเรียนระดับชั้นมัธยมศึกษาตอนต้น โดยการคิดวิเคราะห์เป็นทักษะที่ใช้ในการแยกแยะ เปรียบเทียบ และหาความสัมพันธ์ระหว่างองค์ประกอบ ชุดการสอนแบบความเป็นจริงเสริมเป็นการเปลี่ยนข้อมูลจากภาพสัญลักษณ์ (Marker) ไปยังวัตถุเสมือนที่เป็นรูปธรรม โดยการตรวจจับสีในกรอบสี่เหลี่ยมเล็ก ๆ บนมุมทุกมุมของภาพสัญลักษณ์ การรวมกันของสีเหล่านั้นใช้ในการเชื่อมโยงระหว่างภาพสัญลักษณ์กับวัตถุเสมือนที่สร้างขึ้น การออกแบบในชุดการสอนนี้เป็นการแสดงผลของสถานการณ์จำลอง โดยให้นักเรียนเลือกภาพสัญลักษณ์ที่สอดคล้องกับสถานการณ์มาจัดกระทำ เมื่อนักเรียนจัดกระทำสื่อความเป็นจริงเสริมที่มีการแสดงผลแบบทันทีทันใดในรูปแบบภาพ สื่อความเป็นจริงเสริมจะแสดงข้อมูลเป็นวัตถุเสมือนซึ่งจะช่วยให้นักเรียนรับรู้ข้อมูลแบบรูปธรรมในเวลาทันทีทันใดจากภาพสัญลักษณ์ที่ถูกจัดกระทำ ส่งผลให้นักเรียนสามารถรับรู้และเข้าใจเนื้อหาในระดับที่สูงขึ้นกว่าการนำเสนอข้อมูลจากสื่อที่แยกกัน เครื่องมือที่ใช้ในการวิจัย คือ ชุดการสอนแบบความเป็นจริงเสริม เครื่องมือในการเก็บรวบรวมข้อมูล คือ 1) แบบสอบถามความคิดเห็นผู้เชี่ยวชาญ และ 2) แบบประเมินชุดการสอนแบบความเป็นจริงเสริม สถิติที่ใช้ในการวิจัย คือ ค่าเฉลี่ย และส่วนเบี่ยงเบนมาตรฐาน

ผลการวิจัย พบว่า ชุดการสอนแบบความเป็นจริงเสริมที่ออกแบบและพัฒนาขึ้นเมื่อประเมินคุณภาพโดยผู้เชี่ยวชาญ มีค่าเฉลี่ยเท่ากับ 4.78 ซึ่งหมายถึง โดยรวมชุดการสอนแบบความเป็นจริงเสริมมีความเหมาะสมในการนำมาใช้อยู่ในระดับดีมาก

**คำสำคัญ:** ความเป็นจริงเสริม/การจัดกระทำ/สถานการณ์จำลอง/ความสามารถในการคิดวิเคราะห์

## Abstract

The objectives of this research are design and development of augmented reality (AR) instructional package with simulation method and manipulative learning for enhancing an analytical thinking ability of lower secondary school students. The analytical thinking is a skill for discrimination, comparison and relation between many components. An augmented reality technology (AR) was used to transform markers to virtual objects by detecting color of small squares at each corner of the marker. The combination of those color links to concrete object of that marker. The package is designed as a display of simulation problems requiring students choose a marker choice corresponding to a simulation problem. Students manipulate the learning materials in an augmented reality mode which representing in a real time graphical information. The augmented technology virtualizes a concrete perception in real time to the marker choices that manipulated by students which accommodated students' perception the content in a deeper level than presenting media separately. The research tool is AR instructional package, the data collection tools are questionnaire experts and AR instructional package evaluation form. The collected data are analyzed with statistical tools which are mean and standard deviation.

The result of experts' evaluation is an average of 4.78 which show that the proposed AR instructional package is highly suitable for use in class.

**KEYWORDS:** AUGMENTED REALITY/MANIPULATION/SIMULATION/ ANALYTICAL THINKING ABILITY

## Introduction

The analytical thinking is an essential ability enhancing a diagnostic skill, evaluation skill, decision skills and future planning skill of student. It analyzes the complex problem by finding all possible solutions, evaluates those solutions and selects the best one as an answer. Using that process, the solution is solved by the most suitable reasoning without any bias from a personal reasoning (Chareonwongsak, 2010).

According to the office of the permanent secretary, ministry of education's survey, the analytical thinking ability of Thai students are low, so ministry of education focuses on improvement those skill by emphasizing a learning from a real experience activities and adding more practical activities (Ministry of education, 2012).

In some topic, teachers cannot demonstrate a real situations such as at the hearth topic in the biology subject Campos and Pessanha (2011). The augmented reality technology (AR) solves that problem by visualizing and augmenting more knowledge by adding a video, 3D animation or additional text knowledge to the specific location located by markers or other features which it is more comprehensible than traditional text knowledge. Charoenying and Natakutoong (2013) developed a design model for web-based simulation lessons to enhance decision making ability for learner. Aleksandrov (2014) developed an audiovisual media texts by using an audio-visual learning technologies which it improves students' analytical and projective abilities.

The AR technology simulates virtual objects by perceiving and interacting from a special hardware or a computing device and integrates those objects called the virtual environment to the real word environment which it help learner perceiving a concrete content and better understand (Borrero and Márquez, 2012).

The AR instructional package in simulation method consists of a manual of program, a learning instruction, activities, simulation and marker. The learning activities include of six activities which are an introduction, a simulation problem proposing, a player role discriminating, an activity playing, a conclusion and an evaluation. The materials of an instructional package are alphabets or symbols, figures and videos.

The manipulation forces students practicing by their own ideas and learning from response of activities (Pathak, 2010). Adding the AR technology to learning activities improve a concrete perception, for example students manipulate with markers and markers transform

from symbols to more meaningful objects, and an analytical thinking ability, for example students answer the question by analyzing from the physical of the virtualized object instead of reading the text statements.

This research focuses on designing and developing AR instructional package for improving and analytical thinking ability. The proposed augmented reality use multi marker represented as choices in the answer set. In the remainder of this paper are the objective of study, literature review showing the previous work about adding the augmented reality to the knowledge content, research methodology, results, the implementation, a conclusion, future works and a discussion.

## **Objectives**

The objectives of this research are design and development of AR instructional package with simulation method and manipulative learning to enhance an analytical thinking ability.

## **Literature Review**

The analytical thinking is an ability to separate the whole content to the minor parts and find relation between those parts. (Bloom, 1956) (Clark, 1968) Moreover, the analytical thinking is a reflective thinking starting by thinking at the complex situation and ending at the simple situation (Dewey, 2011). Furthermore, the analytical thinking is an ability to discriminate and classify each component in the topic and find the causal relationship between the elements for analyzing the real reason of the situation. (Chareonwongsak, 2010)

The analytical thinking is divided into 3 aspects, which are

1. Analysis of element is an analyzing whether the fact or the writer's opinion of the element and a finding element that's essentially to the situation.
2. Analysis of relationship is a causal reasoning to the relevant or irrelevant relation between each elements.
3. Analysis of organization principles is a supporting relation by using the principle relating to the topic.

A learning by simulated situation is a simulating of the real environment. Students study with that simulated situation and gather the knowledge for using in a real situation (Joyce, 2009).

A simulated situation is not a game playing for fun and not a role playing but it is a learning without a teacher. The students play a given role in the given situation and make a decision to the situation. The teacher limits the time in that situation and explains the detail and the responsibility of each roles. (Jones, 1980)

Kammanee (2011) proposed that the advantage of using learning by simulated situation helps student understand the complex relation because of the experience with themselves which it draws an attention of the student with fun learning and practices many skills such as an interaction, a communication, a decision, a problem solving and a thinking.

A learning with manipulation forces students practicing, thinking and perceiving form the trial and error experiencing which it helps student to quickly archive the goal (Davies, 1971 cite in Kammanee 2013). Shaw (2002) said that the advantage of manipulation is an improving conclusive thought ability which students can understanding the concept by manipulating themselves with the environment. Cass, Cates, and Smith (2003) said that a manipulating with a media helps student concrete understanding and attentive concentrating the topic.

The application of concerning the manipulating to the learning mathematic topic, Shaw (2002) found that it can improve conclusive thought ability and helps student better understanding the concept of a mathematic subject. Cass, Cates, and Smith (2003) studied about using a manipulation with learning disability students in mathematic subject at an area and a circumference topic. Students who measuring and interacting with a media (manipulating with a media) are concretely understanding the topic and are able to solve the problem. Zacharia and Olympiou (2011) applied a manipulation to a physic subject for creating a new experience of a bachelor's degree learning by using a manipulating between a real object and a virtual object for better understanding the concept of the physic subject.

The augmented reality technology was applied in various topics ((Van Krevelen & Poelman, 2010); (Azuma, 1997); (Yuen, Yaoyuneyong, & Johnson, 2011)). The implementation of an augmented reality requires a set of hardware recognizing an input data and virtualizing augmented information. The earlier augmented reality system requires a specific hardware to implement those functions (Shelton & Hedley, 2002); (Juan, Beatrice, & Cano, 2008) but nowadays, the common devices, such as laptop computer and smart phone, contain hardware which able to implement those functions, so the modern augmented reality systems are implemented to those device (Freitas & Campos, 2008); (Takacs et al., 2008)

Because of the affordable price of the augmented reality system, many researches focus on implementation of the augmented reality system on the educational topic with those devices. The example of the implementation of the augmented reality system are

- An interactive book Billingham and Kato (2002)

An interactive book is a traditional book added on with augmented reality markers on the specific page or figure. Those markers display 3D animation or additional video on the specific page by viewing with a smartphone or a webcam. An interactive book helps learner gaining more understandable than learning with still images.

- A card board gaming Dunleavy (2014)

Some of learning toolkits are designed as a card board gaming. The augmented reality virtualizes the 3D animation or more meaningful information to those cards and helps a learner feeling more reality while playing than using only flat card board.

- A discovery based learning De Lorenzo (2009)

A discovery based learning is an adding on an augmented reality technology to a real world place such as adding an augmented reality marker on a historical place which it can virtualize the additional information by using the learner smartphone with specific application installed on the device. Moreover, the GPS technology send the learner location information to an augmented reality system, so the augmented reality system can virtualize the additional information immediately when the learner enters to an important place without using any marker.

The result from those researcher indicated that the learners have improved their interest and attention with the activity, moreover, Yuen et al. (2011) indicated that using an augmented reality technology embedded to a traditional content can improve analytical thinking of the learner.

## **Research methodology**

### *Processes of Research*

The study was undertaken through the following procedures.

1. Studying about a theory and relative research paper
2. Interviewing 5 professors who are the experts in development of a media for an education about a developing of an augmented reality in simulation method and manipulative teaching

The result from an interviewing are

- Professors agreed about an applying of an augmented reality in a learning, because it motivates students' participation and creates new media style. Some professors suggested that the learning package should combine an augmented reality with other type of media, for example, the solution should be printed out and the learning environment should support a learning with augmented reality.

- Professors agreed about a learning with a manipulation because it emphasize a practice while learning which students learned for the result of a practice. Professors suggested that the learning with manipulation should be references for guiding possible choices.

- Professors agreed about a learning with simulation method adopted with augmented reality for improving a manipulation of students and suggested that it could improve the analytical thinking ability.

- Professors suggest that the media of augmented reality should be images and videos.

- Professors suggest that the aspects of analytical thinking ability that should be evaluated are an element, a relationship and an organization principle.

3. Concluding and analyzing the suggestions of professors for designing a AR instructional package

4. Evaluating the proposed AR instructional package with rating scale by 3 professors, the result is 4.78 (very good)

5. Tryout and testing

#### *Research Instruments*

1. Open-ended questionnaires for professors about development of the AR instructional package.

2. Evaluation form for professors about development of the AR instructional package.

#### *Data Analysis*

Qualitative data were analyzed by content analysis and conclusion.



## Research findings

The proposed AR instructional package consisted of a learning session and a learning activity session. The learning session displays a traditional knowledge content showed as video to a learner. The learning activity session is designed as multiple choice & matching. Instead of showing those question as a plain text, the questions are displayed as a picture or video animation, the choice implemented by an augmented reality technology are shown as an animation corresponding to the displayed question.

This section is divided to two part which are the proposed system flowchart describing the process of the proposed system and the marker designing.

### 1. The proposed system of AR instructional package.

The system flowchart is shown on figure 1 and divided to 8 processes. The detail of those processes are described below.

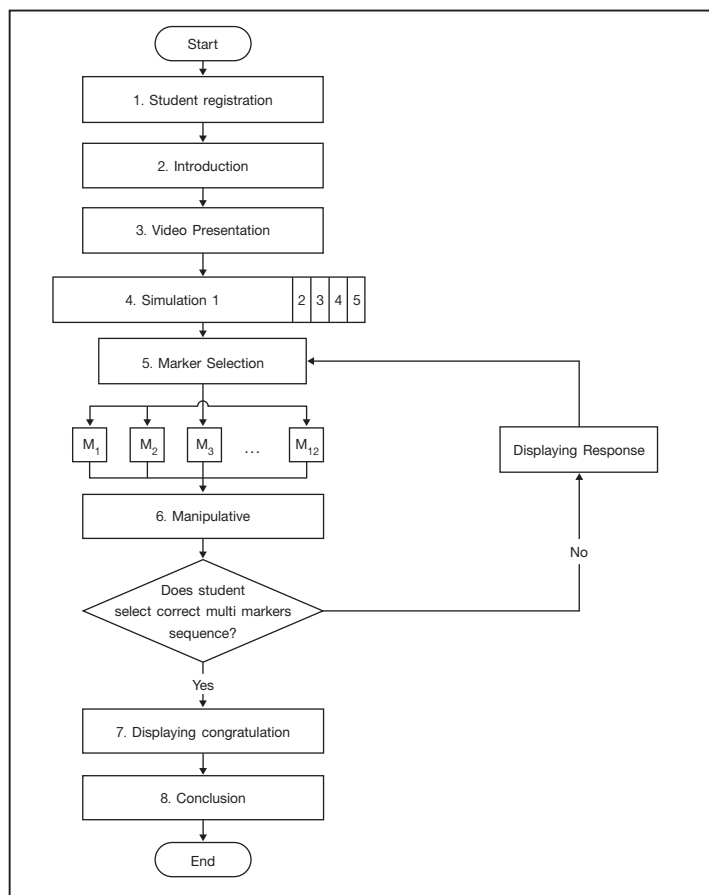


Figure 1 The flow chart of proposed system

1) Student registration

The first step is a student registration step as shown on figure 2. The images related to learning subject is shown in the screen. A student can download a PDF version of a program by clicking at the top-right icon. A student must submit personal information which are a first name, a last name, a grade and a number in a class to proceed to next step.

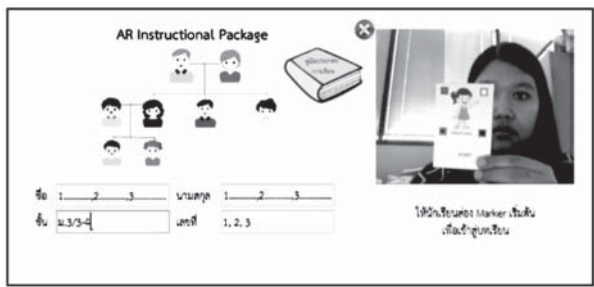


Figure 2 Student registration

2) Introduction

A student carefully reads an instruction on figure 3 before begin studying. A Student clicks at the “Next” button to proceed to next step.

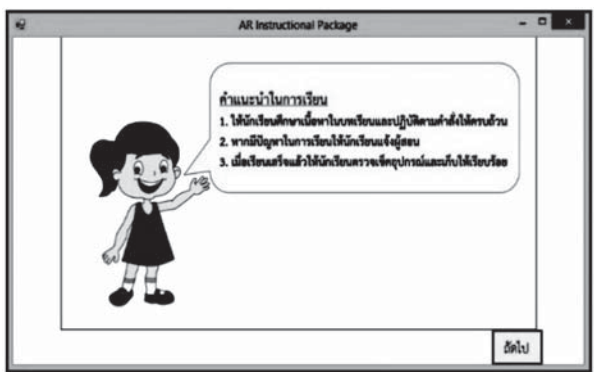


Figure 3 Introduction

### 3) Video Presentation

A student studies a material. The program shows a video content as shown in figure 4. A student can replay and watch the video without a time restriction. After finishing watching a video, a student clicks at the “Next” button to proceed to a testing section.



Figure 4 Showing knowledge video content

### 4) Simulations

The testing section is represented as a simulation which are pictures or videos as shown in figure 5. A student can replay a simulation by clicking at the “Replay” button. If a student understands a simulation, a student clicks at the “Next” button to proceed to an answering section.

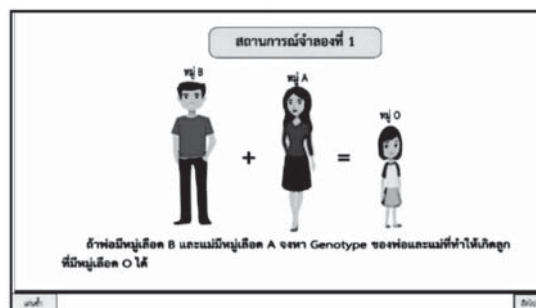


Figure 5 Displaying a simulation

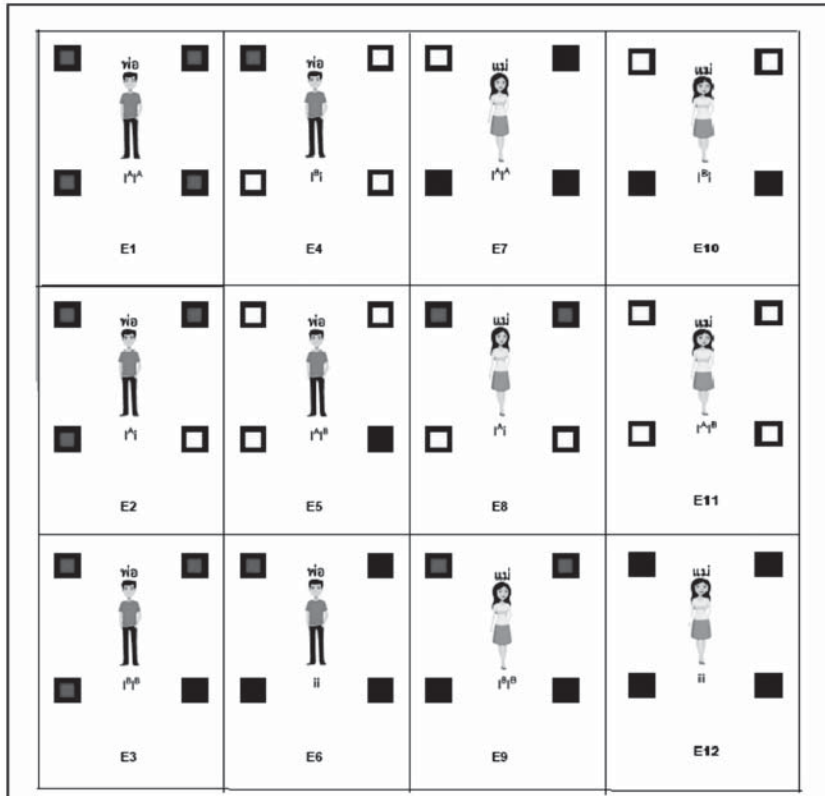


Figure 6 Situation marker

5) Marker Selection

A student selects a situation answered marker from the whole marker as shown on figure 6 and manipulates them on figure 7.



Figure 7 Displaying marker selection command

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Figure 8 Example of manipulation



Figure 9 Response in case of correct



**Figure 10** Response in case of incorrect

7) Displaying congratulation

After a student manipulates all of simulation problems, the screen as shown on figure 11. A student clicks “Next” button to proceed to next step.



**Figure 11** Text displaying when manipulate all of simulation problems

8) Conclusion

In the conclusion section is shown on figure 12. A student is asked to conclude the knowledge gathered from this activity by answering at the text area. After finish the conclusion, a student clicks at save button to finish the activity.



**Figure 12** Conclusion

2. The marker designing for AR instructional package in simulation method with manipulative learning.

According to the requirement in the “Submitting a multi markers sequence” section which it requires the program simultaneous recognition multiple marker and the concept of adding the augmented reality to the choice of the answer, the number of marker are too large. The traditional markers which are discriminated by the picture of the marker don’t suitable for this situation because of the large number of markers are used and it affects to an accuracy of a marker recognition.

The research proposes the new style of marker as shown on figure 8 which contains the four small square on each size of a marker and the marker size must be a square. The four small square on each size of a marker are filled with different color and the combination of those color ignoring the order is used as a feature to discriminate a type of marker.



**Figure 13** Example of markers

The filled colors are white, blue, red and green. The combination of those color produces 36 distinct markers. It mean that the maximum choice appeared in a simulation problem are 36 choices.

### **Implementation**

The program was designed as a window-based application. The C# language was used to implement the main graphical user interface and control the process flowing. The OpenCvSharp-a wrapper of OpenCV for .NET Framework-was used to implement about image processing and webcam controlling. The software requirements are the Microsoft Window 7 or newer version, the Microsoft. Net Framework 4.0 and the webcam driver. The hardware minimum requirements are the third generation Intel Core I series, 4 gigabytes system memory and the HD webcam.

An augmented reality instructional package improves analytical thinking ability of students at the learning with simulated situation process and manipulating process. A applying an augmented reality material with a teaching help student perceiving a concrete object, easy understanding, connecting an idea and gaining analytical thinking skill.

### **Conclusion and Future Work**

Thai student can improve the analytical thinking ability by using an augmented reality technology to a traditional knowledge content such as text book and learning activity improves that ability. This research develops an instructional package by implementing the learning activity using the augmented reality system that added both questions and multiple choice to be more understanding and analytical thinking ability. It helps learner understand the connection between the question and choices easier than traditional text.

The future work of this study is deploying this program to a classroom and evaluating the benefit gained from this program.

### **Discussion**

The data from text book, related research and opinions of professors were analyzed and synthesized for designing an AR Instructional package. The proposed design aim to enhance the analytical thinking ability and was divided to 8 tasks; 1) student register 2) introduction 3) Video presentation 4) simulations 5). Marker selection 6) Manipulation 7) Displaying congratulation and 8) conclusion.

From the literature review found that the teaching by using simulated situation improves the analytical thinking ability of the student because of its practicing functional. Students manipulate simulated situation which student transfer analytical thinking ability solve the real life problem. Many researches focus on a teaching with simulated situation for improving an analytical thinking ability of students. Furthermore Tajai (2011) studied about the teaching by using simulated situation in a forensic science subject for improving an analytical thinking ability of grade 12<sup>th</sup> students. The result shown that the experimental student group had an average score of analytical thinking skill after learning significantly greater than before learning at significant level of 0.05. That research agreed with Davison and Gordon (1978 cited in Jones, 1980) who found that the simulated situation improved an analytical thinking, a critical thinking, a considering and a problem solving skills. In addition Alberta (2011) experienced the fifth grade student with manipulation method at the mathematic



subject. The result showed that the student had an improvement at understanding a complex subject when student manipulated with a concrete object added on by augmented reality. Moreover Campos and Pessanha (2011) studied about a designing of using augmented reality in teaching by using game based for an elementary student. The game based augmented reality called “game board pieces” was played by matching an organism marker with an environment marker. The result shown that it induced and motivated student to concentrate a learning. Student had a low incorrect answer after playing a game, concentrated to a 3D organism, learned while playing, manipulated and solved an answer with them self. The game based augmented reality improved a movement of the elementary student, a collaboration and it also helped student perceiving concrete object which it easy to understand.

This research focuses on developing a manipulation augmented reality in a simulated situation for improving an analytical thinking of students. Its help students practice and manipulating in a simulated situation that brings on abstract idea to concrete knowledge.

## **Recommendations**

1. The AR instructional package in simulation method with manipulative learning can be adopted to suit with other subject.
2. The AR instructional package can be applied to other learning method such as inquiry based learning, problem-based learning and brain-based learning.
3. This proposed program can be ported to handheld device such as mobile phone or tablet which are convenient to learn and access information.

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