Kasetsart Journal of Social Sciences 41 (2020) 40–45

Kasetsart Journal of Social Sciences

journal homepage: http://kjss.kasetsart.org

Effect of 5E instructional model on mobile technology to enhance reasoning ability of lower primary school students

Weeracha Siwawetkul [a], Prakob Koraneekij [b,*]

[a] Master of Education Program in Educational Technology and Communications, Department of Educational Technology and Communications, Faculty of Education, Chulalongkorn University, Bangkok 10330, Thailand
[b] Department of Educational Technology and Communications, Faculty of Education, Chulalongkorn University, Bangkok 10330, Thailand

Article Info

Article history:
Received 12 September 2017
Revised 11 December 2017
Accepted 11 February 2018
Available online 3 March 2018

Keywords:
inquiry-based learning,
mobile learning technology,
reasoning ability,
scientific education,
5E instructional model

Abstract

The objective of the study was to examine the effects of the use of a 5E instructional model on mobile technology to enhance the reasoning ability of lower primary school students (5EMR). The subjects of the study were 30 lower primary school students. The instruments employed in the study consisted of: 1) 5E on a mobile application; and 2) a learning management plan. The data collection instruments comprised: 1) a reasoning ability test; and 2) a reasoning behavior observation form. The results showed that the average reasoning ability of the lower primary student subjects before and after the lessons differed significantly ($p = .05$). In addition, the observation of the reasoning ability of the subjects based on the 14-item checklist showed that the three most frequently exhibited behaviors found in the classroom were: conduct an experiment or an investigation to determine causes of a problem or a phenomenon (96.6%); cite empirical evidence obtained from an investigation or a laboratory experiment in concluding an investigation or responding to a question (96.6%); and utilize the scientific method in researching and investigating (93.3%). The results revealed that 5EMR had positive effects on reasoning ability, intrinsic motivation, reasoning behaviors, and achievement.

Introduction

Nowadays, technology plays the most important role in making lives easier and more efficient. One effective example is in communication which has become faster and easier along with the dissemination of information on social networks. With this development, we can see messages, comments, and expressions that are not rooted in reason and are characterized by indiscretion. The same is true even for opinions expressed in the mass media or by prominent figures in society. This lack of reasoning ability may lead to various social problems related to the order and the management of society, especially when the country is facing a crisis (Whattananarong, 2014). This is consistent with the national test result by the Office of the Basic Education Commission (OBEC, 2013) in which primary school students had an average score of 45.20 percent in the reasoning ability test. This evaluation seems like a signal to instructors and those people involved in the education industry to review and prepare a new model of instruction, in order to develop student performance to the international level.

Reasoning ability is integral to social development as it directly affects a person's use of discretion in processing information and encourages making logical decisions based on information and the facts that have been analyzed. To foster reasoning ability in learners, instructors must be able

* Corresponding author.
E-mail address: prakob.k@chula.ac.th (P. Koraneekij).

Peer review under responsibility of Kasetsart University.

https://doi.org/10.1016/j.kjss.2018.02.005

to teach them to develop advanced thinking skills (Institute for the Promotion of Teaching Science and Technology [IPST], 2003; Sawekngam, 2014).

The 5E instructional model is an instructional model that applies inquiry-based learning. In addition to fostering an understanding of scientific concepts, research skills, analytical thinking, and reasoning skills, this model will help learners to understand the scientific method and how to seek knowledge through the process of science by teaching contents in combination with situational testing that will enable learners to diagnose and solve problems as well as to make appropriate use of the resources available (National Research Council [NRC], 2000; Rodger et al., 2006).

The increasing usage of wireless technology will help to generate an enormous advantage in education if an instructor can teach its use to learners. Learning models that incorporate wireless technology and mobile devices such as a tablet computer, called mobile learning can expand learning scopes compared to traditional models as well as support inquiry-based learning as the technology facilitates the research and exchange of information and opinion. In addition, the efficiency of tablet computers and their capabilities to accommodate multimedia or access various types of information for instance, can boost students' motivation and promote positive attitudes towards learning, which can induce positive changes in learning behavior (Hwang, Wu, & Ke, 2011; Joosten, 2010).

Therefore, the researchers were interested in examining the effect of the 5E instructional model on mobile technology to enhance reasoning ability in lower primary school students. This aimed to blend the 5E instructional model with mobile learning, and to identify the effectiveness of the tablet computer. The program involved student-centered learning with the tablet computer as a main tool. Students were provided with an opportunity to research, examine, brain-storm, summarize, and eventually step into an experiment while the instructor's role in the classroom remained as a facilitator or mentor. This could be beneficial for future applications of the model to other subject areas to develop students' reasoning ability.

Literature Review

The 5E Instructional Model

The 5E instructional model is predicated on inquiry-based learning. In this model, instructors must work with their students, who will feel more motivated to learn when they feel supported by their instructors to generate thought-provoking questions and create hypotheses. The instructional model also promotes rational discussions as well as collaborative problem solving, which ultimately lead to understanding (Gillies, Nichols, Burgh, & Haynes, 2012). In addition, students will also be encouraged to use equipment and technology in making scientific inquiries (Skamp, 2012). Originally, the 5E model consists of five steps: 1) Engagement—this is an introduction to let learners access prior knowledge and engage the new concept through short activities; 2) Exploration—learners will be provided with a common base of activities to seek out for which current concepts are identified and conceptual change is facilitated; 3) Explanation—learners will be provided with opportunities to demonstrate conceptual understanding or behaviors from the data collecting; 4) Elaboration—learners will challenge conceptual understanding through new experiences to develop understanding; and 5) Evaluation—the teacher evaluates student progress toward educational objectives (Rodger et al., 2006).

Mobile Learning

Learning using mobile devices such as a tablet computer aims to facilitate and support the instruction. Furthermore, wireless technology also creates learning opportunities as it can be used anywhere and may also be customized to suit different contexts, learner natures, and environments. This kind of technology also offers ease and convenience and can elevate educational achievement. This learning model is learner-centered in nature and supported by technology (Schofield, West, & Taylor, 2011). Mobile learning creates learning interaction with a mobile device which contains: 1) Content—a direct interaction between learners and a content such as document, pictures, E-books or animation; 2) Compute—an interaction between a learner and applications such as a photography and video recording; 3) Capture—an interaction formed by creating a data; and 4) Communication—interaction when learners exchange of information and opinion (Quinn, 2011).

Reasoning Ability

Reasoning abilities are the abilities to make connections between knowledge, information, and experience and, after engaging in the process of analysis, synthesis, and evaluation, to make logical decisions based on information (OBEC, 2013). Reasoning ability is reflected through behaviors such as verbal, performance, and an ability to accept another's opinion as shown in Table 2 (IPST, 2003; Sawekngam, 2014).

Conceptual Framework

From the literature review of the 5E instructional model, mobile learning, and reasoning ability, the conceptual framework of this research was developed to blend the steps of the 5E instructional model with elements of mobile learning, based on relevant ideas, theories, and studies as shown in Figure 1.

Methods

The 5E instructional model on mobile technology to enhance reasoning ability of lower primary school students used in the experiment was an experimental, one-group, pretest-posttest design.

Participants

The subjects of the study consisted of a class of 30 primary students at Chatturat Wittayanukool School in their second academic year in 2015. They were purposively sampled because the number of students was considered sufficient for the experiment and the sample was equipped with mobile learning devices necessary for the instructional model such as a tablet computer and Wi-Fi Internet.

Materials and Tools

The instruments employed in the experiment were:

1. A 5E instructional model on mobile technology to enhance the reasoning ability of lower primary school students (5EMR) as shown in Figure 1.
2. 5E on a mobile application was employed to introduce learning contents and activities in accordance with the mobile learning system based on the elements and steps of 5EMR. Developed and customized with Wordpress, the mobile-application opted for a responsive template in its design to accommodate the display resolutions of a tablet computer.
3. A learning management plan was developed in accordance with the procedure and elements and steps of the 5EMR model. Situational testing was used to present the content, which aimed at fostering scientific reasoning abilities as show in Figure 2.

Data Collection

The data collection instruments employed in the study were:

1. Reasoning ability tests. Two reasoning ability tests were developed, each consisting of 20 four-answer choice items. Each item tested scientific knowledge and provided a problem situation, along with an article, images, or captions to further elaborate on the given situation. One was administered as a pre-test, and the other as a post-test.

2. Behavior observation form. This was a checklist consisting of two sections classified by modes of observation. The first section was for in-class behavior observation, consisting of nine behaviors, while the second section was for observation of behavioral evidence and clues, featuring five behaviors. Altogether, the observation form contained 14 behaviors, as show in Table 2.

Data Analysis

Differential analysis was undertaken with the averages of reasoning ability obtained from the reasoning ability test administered in Week 1 and Week 8, using a dependent t-test and the results of reasoning behaviors from the observation form (checklist) employed during learning activities in the first classes of learning program in Week 2 and the last classes in Week 7.

Results

1) Analysis of the differences of the average scores of reasoning ability showed that there was a difference at the .001 level ($t = -4.149$, sig = .000). The scores from the post-test ($x = 11.76$, SD = 3.578) were higher than the scores from the pre-test ($x = 8.73$, SD = 2.347) as detailed in Table 1.

Table 1
Analysis of the difference of the average scores of reasoning ability

Reasoning ability	N	Mean	SD	t	Sig.
Pre-test	20	8.73	2.347	−4.149	.000
Post-test	20	11.76	3.578		

Table 2
Results of observation of reasoning behaviors

Behavior observed	Observation in Week 2		Observation in Week 7	
	Number of encountered behaviors	Percentage of encountered behaviors	Number of encountered behaviors	Percentage of encountered behaviors
1. Cite causes and effects when discussing a subject matter	19	63.3	23	76.6
2. Cite reasons when writing or speaking about a subject matter	20	63.3	22	73.3
3. Ask questions that seek to identify the cause of the problem	11	36.6	13	43.3
4. Utilize the scientific method in researching and investigating	22	73.3	28	93.3
5. Ask questions about the rationale of issues that classmates discuss	15	50	18	60
6. Verify explanations or opinions on issues being discussed in class before accepting them	18	60	19	63.3
7. Conduct an experiment or an investigation to determine causes of a problem or a phenomenon	28	93.3	29	96.6
8. Identify relations between causes and effects of an investigated problem in written discussion of the results	12	40	15	50
9. Record information during an investigation	20	66.6	22	73.3
10. Make additional information searches and inquiries to obtain evidence to be used when concluding from the results	12	40	17	56.6
11. Cite empirical evidence obtained from an investigation or a laboratory experiment in concluding an investigation or responding to a question	27	90	29	96.6
12. Cite empirical evidence obtained from an investigation when making an argument or a counterargument	10	33.3	13	43.3
13. Engage classmates and instructors in a discussion or questions about obtained information or investigation results	15	50	22	73.3
14. Make use of information from additional information resources in verifying investigation results	14	46.6	15	50

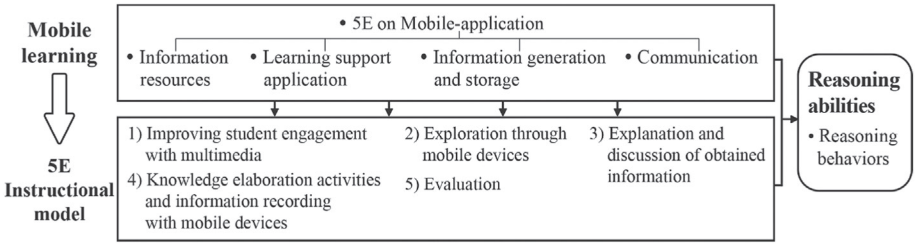

Figure 1 Conceptual framework

2) The reasoning ability behavior of the 30 students was observed in class twice in Week 2 and Week 7, using the checklist of 14 reasoning behaviors. The number of times each behavior was demonstrated was counted, as shown in Table 2.

The results of the observation of the subjects based on the 14-item checklist showed the percentages of all encountered reasoning behaviors in Week 7 were higher than in Week 2.

Discussion and Conclusion

This study examined the performance of the 5E instructional model on mobile technology to enhance the reasoning ability of lower primary school students (5EMR). The results showed that 5EMR can significantly enhance the reasoning ability; the average reasoning ability scores in the post-test were significantly higher than pre-test ($p = .001$). Previous studies indicated that applying the 5E model has a positive effect on enhancing students' behaviors, achievement, and attitude towards science instruction (Lin et al., 2014). To further enhance students, the use of technology to support the 5E model such as videos and animation, can help spark interest and prompt eagerness in engaging in subsequent activities (Cigdem, Seda, & Savas, 2014).

Similar to these studies, we also adopted the 5E model as the instructional strategy. However, it differed from the previous studies in that we applied mobile learning elements in each step of the 5E instructional model. In the following section, we discuss why mobile learning elements can be effectively integrated into the 5E instructional model to positively affect students' reasoning behaviors which lead to reasoning ability in a practical dimension.

Step 1: Improving student engagement with multimedia. This step required the capability of a tablet computer to play multimedia such as animations, which can stimulate interest and enjoyment especially in primary students. This is consistent with the findings from the observations that revealed that most of the students carried out activities in strict adherence to the instructions given. This was consistent with an assertion made by Huang, Liang, Su, and Chen (2012), who stated that multimedia can boost learners' understanding of information, enhance their perceptive ability, and create a learning environment that is friendly, accessible, and interesting for learners.

Step 2: Exploration through mobile devices. This step encouraged learners to search for further information so that they could conduct searches independently and access various resources such as E-books and learning resources on the Internet using the tablet computer that contained sufficient information to answer their questions. The results corresponded with a statement by Hogan and Berkowitz (2000) who asserted that instructors can design lessons in accordance with the context, environment, and learning resources available, so that students learn scientific contents through an inquiry-based process. Similarly, Ahmed and Parsons (2013) stated that mobile devices and software can help learners take advantage of learning resources faster and more conveniently, which supports inquiry-based learning.

Step 3: Explanation and discussion of obtained information. This step required learners to analyze and explain the concepts and information derived from the second step as well as to synthesize them into their own body of knowledge and use the tablet computer to capture and create data, in the form of notes, drawings, or mind maps. Then, they were asked to start a group discussion in which they exchanged information and cooperatively proposed solutions for the problem. The learning process taking place at this step echoed a statement by Hwang et al. (2011) that knowledge connection such as the use of concept maps can help learners organize data, findings, and information that they have garnered from their investigation, before synthesizing them into products and engaging in group discussions. In addition, knowledge connection also enhances learners' learning efficiency.

Step 4: Knowledge elaboration activities and information recording with mobile devices. This step required learners to apply the body of knowledge they had gained from the first three steps to group experiments or activities related to the content that encouraged learners to use and extend their knowledge and skills to new circumstances. This was consistent with the findings from observation that revealed that most of the students were eager to engage in class activities and conduct experiments strictly in accordance with the instructions given, because when students see scientific experiments and equipment, they feel excited and interested to learn in different context, which could be held in classrooms, laboratories, or out of school and the tablet computer offered convenience in, for instance, reviewing the content, or viewing videos of experiment demonstrations. After these experiments or activities, learners took photographs of evidence of the experiments or activities using the tablet computer to supplement their

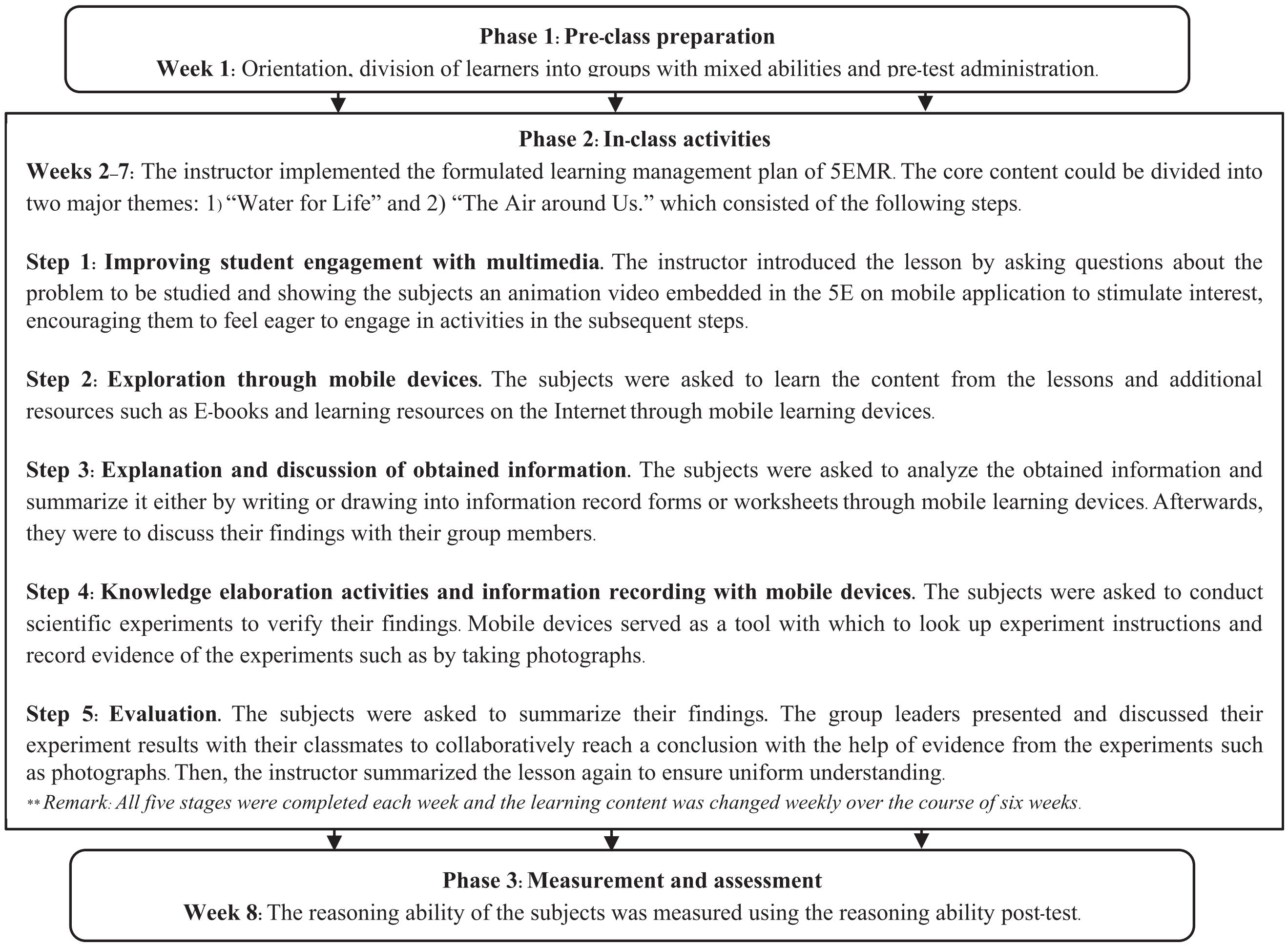

Figure 2 Learning management plan for 5EMR

discussion of the results. Also relevant to this step are the findings by Lin et al. (2014), which showed that when using science kits to perform scientific experiments, students can discover and observe phenomena related to scientific principles, which they can then explain to their instructors or group members to supplement their discussion. This will make it easier for the instructor to explain scientific terminology and concepts as learners have already experienced the actual experiment as well as boosting learning efficiency.

Step 5: Evaluation. This step involved an evaluation of learners' knowledge and reasoning abilities. In this step, the learners verified and discussed the results of their experiments or activities with their classmates to cooperatively draw conclusions or decisions based on the information and evidence from the experiments or activities. This was supported by the findings from observation that revealed that most of the students made use of empirical evidence. They incorporated photographs (both their own and from members of their group) using the tablet computer, as evidence and for verification before writing a summary or responding to a question. This step was consistent with findings made by Gillies, Nichols, Burgh, and Haynes (2013) that science instruction and activities, when coupled with questions that prompt students to draw conclusions, can teach students how to conduct research, make inquiries, and exercise discretion and reason when responding to questions. Learners will be required to investigate, test their hypotheses, solve problems, offer explanations, anticipate, and summarize problems.

The results of this study showed that, the 5E instructional model on mobile technology could foster reasoning ability, reasoning behaviors, and intrinsic motivation in lower primary school students, and not only increased student achievement in learning but also enabled the students to make relationships between the real events and the scientific concepts. A tablet computer was the main instrument, with its use aiming to facilitate and support each step of 5EMR, with the instructor's role in the classroom being as a facilitator or mentor to lead the way to use the tablet for educational purposes and to instruct learners how to use the mobile device. Furthermore, the limitations of the Wi-Fi Internet and mobile learning devices available in schools should also be taken into consideration. For instance, each tablet computer should be inspected beforehand to ensure that it is ready to use. Any technical problems may hinder the lesson and induce boredom in learners; the instructor should have prior experience in preparing and controlling the class as well.

Conflict of interest

There is no conflict of interest.

Acknowledgments

The authors would like to express sincere appreciation to the 90th Anniversary of Chulalongkorn University Fund (Ratchadaphiseksomphot Endowment Fund) for supporting this research study.

References

Ahmed, S., & Parsons, D. (2013). Abductive science inquiry using mobile devices in the classroom. *Computers & Education, 63*, 62–72. https://doi.org/10.1016/j.compedu.2012.11.017.

Cigdem, S., Seda, C., & Savas, G. (2014). Examining usage trends of computer support of the prospective primary school teachers in the science education based on the 5E model. *Procedia – Social and Behavioral Sciences, 116*, 1913–1918. https://doi.org/10.1016/j.sbspro.2014.01.494.

Gillies, R. M., Nichols, K., Burgh, G., & Haynes, M. (2012). The effects of two strategic and meta-cognitive questioning approaches on children's explanatory behaviour, problem-solving, and learning during cooperative, inquiry-based science. *International Journal of Educational Research, 53*, 93–106. https://doi.org/10.1016/j.ijer.2012.02.003.

Gillies, R. M., Nichols, K., Burgh, G., & Haynes, M. (2013). Primary students' scientific reasoning and discourse during cooperative inquiry-based science activities. *International Journal of Educational Research, 63*, 127–140. https://doi.org/10.1016/j.ijer.2013.01.001.

Hogan, K., & Berkowitz, A. R. (2000). Teachers as inquiry learners. *Journal of Science Teacher Education, 11*(1), 1–25. Retrieved from https://tinyurl.com/y989a38x.

Huang, Y. M., Liang, T. H., Su, Y. N., & Chen, N. S. (2012). Empowering personalized learning with an interactive e-book learning system for elementary school students. *Educational Technology Research and Development, 60*(4), 703–722. https://doi.org/10.1007/s11423–012–9237–6.

Hwang, G. J., Wu, P. H., & Ke, H. R. (2011). An interactive concept map approach to supporting mobile learning activities for natural science courses. *Computers and Education, 57*(4), 2272–2280. https://doi.org/10.1016/j.compedu.2011.06.011.

Institute for the Promotion of Teaching Science and Technology. (2003). *Scientific measurement and evaluation manual*. Retrieved from http://sa.ipst.ac.th/?p=682.

Joosten, T. (2010, June 11). *Mobile learning and social media: Increasing engagement and interactivity* [Blog post]. Retrieved from https://tinyurl.com/yb69e4fk.

Lin, J. L., Cheng, M. F., Chang, Y. C., Li, H. W., Chang, J. Y., & Lin, D. M. (2014). Learning activities that combine science magic activities with the 5E instructional model to influence secondary-school students' attitudes to science. *Eurasia Journal of Mathematics, Science and Technology Education, 10*(5), 415–426. Retrieved from https://tinyurl.com/ycqblfpy.

National Research Council. (2000). *Inquiry and the national science education standards: A guide for teaching and learning*. Retrieved from https://tinyurl.com/yce3rxpu.

Quinn, C. N. (2011). *Designing mLearning*. Retrieved from https://tinyurl.com/3xoqjba.

Rodger, W., Joseph, A., April, G., Pamela, V. S., Janet, C. P., Anne, W., et al. (2006). *The BSCS 5E instructional model: Origins, effectiveness, and applications*. Retrieved from https://tinyurl.com/y72hqy5l.

Sawekngam, W. (2014). *Teachers as learners: Reasoning abilities* [Video file]. Retrieved from https://tinyurl.com/ybr5wmzk.

Schofield, C. P., West, T., & Taylor, E. (2011). *Going mobile in executive education: How mobile technologies and changing the executive learning landscape* (Research for UNICORN). London, UK: Ashridge & UNICORN. Retrieved from https://tinyurl.com/y75xgjkc.

Skamp, K. (2012). *Teaching primary science: Trial-teacher feedback on the implementation of primary connections and the 5E model*. Retrieved from https://tinyurl.com/ybhn6x8e.

The Office of the Basic Education Commission. (2013). *Literacy, numeracy & reasoning abilities*. Retrieved from http://bet.obec.go.th/index/.

Whattananarong, K. (2014, November 21). *The development of basic reasoning skills*. Thairath. Retrieved from http://www.thairath.co.th. [in Thai]