THE DEVELOPMENT OF INQUIRY MODEL (5Es) BASED INSTRUCTIONAL PACKAGE FOR GRADE 10 STUDENTS ON "BIOMOLECULES"

การพัฒนาชุดกิจกรรมการเรียนตามรูปแบบการจัดการเรียนรู้แบบสืบเสาะหาความรู้ (5Es) สำหรับนักเรียนชั้นมัธยมศึกษาปีที่ 4 เรื่อง สารชีวโมเลกุล

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Abstract: This research presents the development of inquiry model (5Es) based instructional package for grade 10 students on "Biomolecules". The sample group was chosen using cluster random sampling and consisted of 43 grade 10 students (academic year 2017) from a high school in Nonthaburi Province. The tools for data collection were a learning achievement survey form on "Biomolecules", an analytical thinking ability survey form on biomolecules, a post-instructional package record, and student learning records. The research methodology was a one group pretest-posttest design. The data was analyzed by using mean, percentage, standard deviation, and t-test for dependent samples.

The results of the research reveal that the efficiency of the 5Es instructional package on biomolecules or E_1/E_2 was 81.20/80.10. The students' posttest scores and analytical thinking score were higher than their pretest ones, with a statistical significance at 0.01 level.

Keywords: Instructional Package; Inquiry Model (5Es); Efficiency; Learning Achievement; Analytical Thinking Ability

บทคัดย่อ: การวิจัยนี้นำเสนอการพัฒนาชุดกิจกรรมการเรียนตามรูปแบบการจัดการเรียนรู้แบบสืบเสาะหาความรู้ (5Es) สำหรับนักเรียนชั้นมัธยมศึกษาปีที่ 4 เรื่อง สารชีวโมเลกุล กลุ่มตัวอย่างที่ใช้ในการวิจัยประกอบด้วย นักเรียนชั้นมัธยมศึกษาปีที่ 4 ปีการศึกษา 2560 โรงเรียนมัธยมแห่งหนึ่งในจังหวัดนนทบุรี ซึ่งได้มาโดยวิธีการสุ่มแบบกลุ่ม (cluster random sampling) จำนวน 43 คน เครื่องมือที่ใช้ในการเก็บรวบรวมข้อมูลได้แก่ แบบทดสอบวัดผลสัมฤทธิ์ทางการเรียน แบบวัดความสามารถในการคิดวิเคราะห์ บันทึกหลังการจัดการเรียนรู้ของผู้วิจัย และบันทึกการเรียนรู้ของนักเรียน แบบแผนการวิจัยแบบ one group pretest – posttest design สถิติที่ใช้ในการวิเคราะห์ข้อมูลได้แก่ ค่าเฉลี่ย ค่าร้อยละ ส่วนเบี่ยงเบนมาตรฐาน (S.D.) และสถิติการทดสอบที่ (t-test for dependent samples)

ผลการวิจัยพบว่า ประสิทธิภาพของชุดกิจกรรมการเรียนตามรูปแบบการจัดการเรียนรู้แบบสืบเสาะหาความรู้ (5Es) เรื่อง สารชีวโมเลกุลมีประสิทธิภาพ หรือ E_1/E_2 เท่ากับ 81.20/80.10 ผลสัมฤทธิ์ทางการเรียนและความสามารถในการคิดวิเคราะห์หลังเรียนสูงกว่าก่อนเรียนอย่างมีนัยสำคัญทางสถิติที่ระดับ .01

คำสำคัญ: ชุดกิจกรรมการเรียน การจัดการเรียนรู้แบบสืบเสาะหาความรู้ (5Es) ประสิทธิภาพ ผลสัมฤทธิ์ทางการเรียน ความสามารถในการคิดวิเคราะห์

1. INTRODUCTION

Science is the systematic study of the structure and behavior of the physical, social, and natural worlds through observation and experimentation, so science is important for human development, especially in the development of research and systematic problem-solving skills. It is deemed necessary for everyone to have some forms of science knowledge management to improve analytical thinking and knowledge application skills [1].

According to public data, the results of the Ordinary National Educational Test (O-NET) in science for grade 12 students were found to be dismal, with the average score being 33.40 and 31.62 for academic year 2015 and 2016 respectively [2]. It was also found that the PISA (Program for International Student Assessment) test score in 2015, which reflected the average score for students at the national level, was 421, less than the 444 score in 2012. Based on the statistics of the PISA test, only Indonesia scored lower than Thailand, while Singapore and Vietnam were among the top ten groups of the PISA participants [3]. The PISA test shows that the development of scientific knowledge in Thailand was low when compared to other countries, which could be due to the fact that the science learning management system in Thailand focuses on memorization rather than understanding. Also, most instructors tend to focus on content over other learning processes despite the fact that good learning management is not just about knowledge transfer, but also the practical application of knowledge [4]. As a result, learners ends up with a low analytical thinking ability, as well as a low learning achievement.

The 5Es inquiry model is a good example of a learner-centered learning management that allows learners to gather information from multiple sources [5] through the 5 steps of learning management: 1) Engagement, 2) Exploration, 3) Explanation, 4) Elaboration and 5) Evaluation [6]. The instructor must encourage questioning that allows learners to use a thinking process that involve analysis, reasoning, and finally knowledge or problem solution [7]. This method will improve the analytical thinking ability of learners, as well as their attitude towards science-learning [8]. However, this model has limitations including a lengthy preparation time and a possible lack of attractiveness of certain topics [9]. Therefore, to create an effective learning management tool, the instructor must create suitable instructional activities and couple them with attractive media or other innovate tools. For this reason, instructional activity becomes important for learning management as it is the concurrent set of activities that allows learners and the instructor to explore the topics on a practical level. The learning materials and the instructor activities are interleaved within the instructional package [10]. The instructional package is a mixed-media package that can provide a multiple-sourced learning to support independent problem solving and freedom of learning for learners [11].

Based on the potential problems and the significance of science learning management, the researcher is interested in the development of the 5Es instructional package for biomolecules as a concept for instructional package creation, and promotion of learning achievement and analytic thinking ability development in grade 10 students.

2. RESEARCH OBJECTIVES

The objectives of this research were as follows:

1) To develop the 5Es instructional package for biomolecules that has efficiency 80/80.
2) To compare the difference between pre-test and post-test learning achievements of grade 10 students using the 5Es instructional package for learning “biomolecules”.
3) To compare the difference between pretest and posttest analytical thinking abilities of grade 10 students using the 5Es instructional package for learning “biomolecules”.

3. HYPOTHESES

The hypotheses of this research were as follows:

1) The 5Es instructional package for biomolecules that has efficiency 80/80.
2) The learning achievement of students after learning with the 5Es instructional package is higher than before learning with statistical significance at 0.01 level.
3) The analytical thinking abilities of students after learning with the 5Es instructional package is higher than before learning with statistical significance at 0.01 level.

4. RESEARCH METHODOLOGY

4.1 THE SAMPLE GROUP

The sample group was 43 grade 10 students of Mathematics-Science Program from a school in the Nonthaburi Province. The sample group was chosen using cluster random sampling.

The research was conducted at the first semester of the academic year 2017. The instructional package lasted for 12 periods with 50 minutes for each one.

4.2 RESEARCH VARIABLES

The variables of this study were as follows:

1) The independent variable is the 5Es instructional package for biomolecules
2) The dependent variables were:
   2.1) The efficiency of the 5Es instructional package in biomolecules
   2.2) Learning achievement in biomolecules
   2.3) Analytical thinking ability in biomolecules

4.3 RESEARCH TOOLS

There were two types of research tools used in this study.

1) Experimental tool:
   1.1) The 5Es instructional plan
   1.2) The 5Es instructional package for biomolecules
2) Data collection tool:
   2.1) A biomolecules learning achievement assessment for grade 10 consisting of thirty multiple choice questions.
   2.2) A biomolecules analytic thinking ability assessment consisting of five written questions.
   2.3) A post-instructional package record
   2.4) Student’s learning records

4.4 DATA COLLECTION

Data was obtained via the following methods:

1) A pretest for the sample using the learning achievement assessment form and the analytical thinking ability assessment form for biomolecules, with 50 minutes for each assessment.
2) The uses of the 5Es instructional package in biomolecules for 12 periods, 50 minutes per period.
3) A posttest for the sample using the biomolecules learning achievement assessment form and the analytical thinking ability assessment form, with 50 minutes for each assessment. Both of the posttest assessment forms were identical to the pretest ones.
4) Grading the completed learning achievement and analytical thinking ability assessment forms.
5) Analyzing the biomolecules learning achievement and analytical thinking ability assessment scores to validate the hypothesis.
6) Summarizing the data analysis.

4.5 DATA ANALYSIS

The data analysis of this study were as follows:

1) To determine the efficiency of the 5Es instructional package in biomolecules. E_1/E_2 would be analyzed.
2) To compare the difference between pretest and posttest learning achievement or analytical thinking ability of grade 10 students using the 5Es instructional package for the biomolecules. A t-test for dependent samples would be utilized.

5. RESULTS

This study involved the development of the 5Es instructional package on biomolecules. The comparison of the learning achievement and the analytical thinking ability of the students are presented in the following tables.

Table 1. The efficiency of the 5Es instructional package on biomolecule using 30 grade 10 students.

5Es instructional package in biomolecules (Set nos.)	Full Scores	$E_1(\overline{X})$	E_1 (%)	Full Scores	$E_2(\overline{X})$	E_2 (%)	E_1/E_2
1	10	7.90	79.00	10	8.12	81.20	79.00/81.20
2	10	7.93	79.30	10	8.08	80.80	79.33/80.80
3	10	7.80	78.00	10	7.89	78.90	78.00/78.90
4	10	7.93	79.30	10	7.92	79.20	79.33/79.20
5	10	8.17	81.70	10	7.88	78.80	81.67/78.80
6	10	8.57	85.70	10	8.12	81.20	85.67/81.20
7	10	8.57	85.70	10	8.06	80.60	85.67/80.60
Average	10	8.12	81.20	10	8.01	80.10	81.20/80.10

Table 1 shows that the 5Es instructional package on biomolecules for grade 10 students has an efficiency or E_1/E_2 of 81.20/80.11. This resulted from the students' high level of cooperation and engagement. The students learnt by employing all five facets of the 5Es package, which is the primary reason for the high efficiency score.

Table 2. A comparison of average score of pretest and posttest of biomolecules learning achievement of the sample group using a t-test.

Learning Achievement	Full Scores	$\overline{X}$	S.D.	T	p-value
Pretest	30	11.42	2.17	-27.54	0.000*
Posttest	30	24.02	3.06		

Table 2 presents the analysis and the comparison of the pretest and posttest biomolecules learning achievement score using a t-test. It was found that the average posttest score ($\overline{X}$ =24.02, S.D.=3.06) are statistically higher than the pretest score ($\overline{X}$=11.42, S.D.=2.17) at 0.01 level. Thus, the 5Es instructional package for the biomolecules can improve learning achievement in biomolecules.

When the pretest and posttest learning achievement scores were compared on the three levels of the learning process (knowledge-memory, understanding and analytical thinking), the results were shown in Table 3.

Table 3. A Comparison of the pretest and posttest biomolecules learning achievement scores using t-test on three levels of the learning process.

Learning Process	Testing	Full scores	$\overline{X}$	S.D.	t	p-value
Knowledge-Memory	Pretest	7	3.60	0.90	-16.63	0.000*
	Posttest		6.20	0.67		
Understanding	Pretest	12	4.56	1.01	-22.04	0.000*
	Posttest		9.89	1.37		
Analytical Thinking	Pretest	11	3.26	1.09	-18.03	0.000*
	Posttest		7.93	1.82		

Table 3 shows that when the pretest and posttest biomolecules learning achievement scores were compared over the three levels of knowledge-memory, understanding and analytical thinking, it was found that the average posttest score of knowledge-memory ($\overline{X}$=6.20, S.D.=0.67), understanding ($\overline{X}$=9.89, S.D.=1.37), and analytical thinking ($\overline{X}$ =7.93, S.D.=1.82) were higher than the pretest score ($\overline{X}$ =3.60, S.D.=0.90, $\overline{X}$ =4.56, S.D.=1.01 and $\overline{X}$ =3.26, S.D.=1.09), respectively. Thus, the 5Es instructional package for the biomolecules can improve three levels of the learning process in biomolecules.

Table 4. Comparison of the pretest and posttest of biomolecules analytical thinking ability using t-test.

Analytical Thinking Ability	Full Scores	$\overline{X}$	S.D.	t	p-value
Pretest	20	5.12	1.66	-19.32	0.000*
Posttest	20	13.60	3.53		

Table 4 presents that analysis and comparison of the pretest and posttest biomolecules analytical thinking ability score using a t-test. It was found that the average posttest learning scores ($\overline{X}$=13.60, S.D.=3.53) were statistically higher than the pretest score ($\overline{X}$=5.12, S.D.=1.66) at 0.01 level. Thus, the 5Es instructional package for the biomolecules can improve analytical thinking ability in biomolecules.

6. CONCLUSIONS AND DISCUSSIONS

The efficiency of 5Es Inquiry model for the instructional package on biomolecules has an E_1/E_2 of 81.20/80.10, which is more than the 80/80 as specified. The high efficiency rate could be due to the instructional package developed by the researcher was created after an extensive study on related theories of science learning management and content modification to allow effective learning experimentation and discoveries by

learners. Moreover, the instructional package has also been evaluated by experts, and thus, has a high efficiency. This is in congruence with the concepts created by Nachai S. [12] and Sangpho C. [13], who state that the 5Es instructional package is centered on learners, who are allowed to independently search for knowledge from various sources in order to acquire and analyze information, data, facts or solutions through thinking and reasoning processes. With this, learners will be able to independently solve problems. This is also in concurrence with the study conducted by Sriwilai W. [14] on the creation of a science-based instructional package (Flora) for grade 10 students by combining the 5Es and STAD cooperative learning methods. The study showed that the science instructional package (Flora) has an efficiency or E_1/E_2 of 82.06/84.11, which is also higher than as specified 80/80.

The results of the biomolecules learning achievement assessment shows that the grade 10 students who used the 5Es instructional package for biomolecules have higher post-test learning achievement (knowledge-memory, understanding and analytical thinking) score than the pretest ones, with a statistical significance at 0.01 level. As the 5Es instructional package generally focuses on learners, allowing learners to independently do research and develop their own ideas. The knowledge obtained from the instructional package is genuinely useful for learners, which allows for longer memory and applications in everyday life. Learners are automatically exposed to the five steps of thought processes and scientific methods in continuous cycles, allowing appropriate skill development in congruence with Piaget's theory of cognitive development. The exploration step is the one that learners adjust to by the process of assimilation. As in this step, learners actually execute the answer-searching mechanics to find the answers. The step of explanation is associated with accommodation adjustment. As in this step, learners analyze the obtained data or answers using thought processes and knowledge elaboration. Later on, learners will build on or implement knowledge in new situations in conformity with the concept presented by Meewan D. [11], who states that an instructional package is a mixed-media tool, which can create an experience for learners to independently learn and develop problem-solving skills with the freedom to choose their own sources of knowledge. This is also in concert with the study conducted by Acisi S. et.al. [15] on effects of the 5Es learning model on students' academic achievements in movement and force issues. The study showed that students in the experimental group (5Es learning model) are more successful than those in the control group (traditional method) with statistical significance at 0.05 level. Moreover, this is also in line with the results of a study by Demiricioglu G. [16] on the effects of the 5Es instructional package for chemical solutions, which revealed that the students using the 5Es instructional package had a higher learning achievement and a higher chemistry concept scores than the students using the traditional instructional package, with a statistical significance at 0.05 level.

The results of the analytical thinking ability assessment for biomolecules shows that the grade 10 students using the 5Es instructional package for biomolecules have higher posttest analytical thinking ability scores than their pretest scores, with a statistical significance at 0.01 level. As the 5Es instructional package assists students in the search of knowledge and in solving problems independently, this allows full-thought development, the use of reasoning in lesson analysis, and also improve in the development of systematic thinking skills. Moreover, the 5Es instructional package also comes with a set of analytical reasoning questions, especially in the elaboration step in which the researcher has learners analyze and explain a provided article or a situation using the knowledge obtained from previous steps. The student will not only memorize the information, but will also learn to connect or explain other situations, which is in conformity with the study by Karsli F. et.al. [17] on developing a laboratory activity by using the 5Es learning model on student learning with factors affecting the reaction rate and improving scientific process skills. The study showed that the laboratory activity based on 5Es learning model can improve scientific process skills. This is in agreement with a study conducted by

Sukhumduang S. [18] on the comparison between science learning achievement and analytical thinking ability of grade 10 students, between the 5Es group and the traditional group, with the results revealing that the students under the 5Es learning management system had higher learning achievement and analytical thinking ability compared to the traditional group, with a statistical significance at 0.01 level.

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REFERENCES

[1] Ministry of Education. 2008. **The Basic Education Core Curriculum B.E. 2551 (A.D. 2008)**. Bangkok: Ministry of Education.

[2] Office of the Basic Education Commission. 2016. **Policy for Fiscal Year 2017, Office of the Basic Education Commission**. Bangkok: The Agricultural Co-operative Federation of Thailand., Ltd.

[3] The Institute for the Promotion of Teaching Science and Technology. 2017. **Summary of PISA 2015.** Bangkok: The Institute for the Promotion of Teaching Science and Technology.

[4] Tippayatat, P., Phrombun, S. 1999. **Student Advancement Project in Bangkok Schools**. Bangkok: Faculty of Education Srinakarinwirot University.

[5] Ballone D. 2004. The 5Es Instructional Model : A Learning Cycle Approach for Inquiry-Based Science Teaching. **The Science Education Review**. 3(2), P. 49-58.

[6] Moondaeng S. 2011. **Science Teaching Seminar**. Bangkok: Ramkhamhaeng University Press.

[7] Bybee R. et.al,. 2009. A Commissioned Paper Prepared for a Workshop on Exploring the Intersection of Science Education and the Development of 21st Century Skills .**The BSCS 5Es Instructional Model and 21st Century Skills.** New York : The National Academies Board on Science Education.

[8] Kanchanarakpong S. 2006. **Thinking Skills Assessment Manual**. Bangkok: Than Aksorn, Ltd.

[9] Kattiyaman, W., Weerathammo, A. 2006. **Teaching for Thought Improvement.** Bangkok: Theme Printing.

[10] Kuanhavej B. 1999. **Education Innovation (4th Edition)**. Bangkok: Chulalongkorn University Press

[11] Meewan D. 2009. **Study on Science Learning Achievement and Science Problem-solving Ability of Grade 11 Students under Science Problem-solving Instructional Package.** Master of Education, Srinakarinwirot University.

[12] Nachai S. 2010. **Improvement of Physics Learning Achievement and Science Problem-Solving Ability of Grade 11 Students by Using 5Es Inquiry.** Master of Education Thesis (Science Education), Khonkaen University.

[13] Sangpho C. 2016. A Laboratory Set of a Microcontroller for Controlling a Robot. **Journal of Industrial Education,** 15(2), P.126-131.

[14] Sriwilai W. 2013. **Creation of an Instructional Package for Learning Area of Science (Flora) for Grade 4 Students by Integration of 5E Model and STAD Technique.** Master of Education Thesis (Science teaching), Burapa University.

[15] Acisi S. et.al,. 2011. Effects of the 5Es Learning Model on Students' Academic Achievements in Movement and Force Issues. **Procedia Social and Behavioral Sciences**, 47, P. 2459-2462.

[16] Demiricioglu, G., Cagatay, G. 2014. The Effects of Laboratory Activities Based on 5Es Model of Constructivist Approach on Grade 9 Students' Understanding of Solution Chemistry. **Procedia Social and Behavioral Sciences**, 116, P. 3120 – 3124.

[17] Karsli F. et.al,. 2014. Developing a Laboratory Activity by Using 5Es Learning Model on Student Learning of Factors Affecting the Reaction Rate and Improving Scientific Process Skills. **Procedia Social and Behavioral Sciences**, 116, P. 663-668.

[18] Sukkhumduang S. 2016. **A Comparative of Grade 4 Students' Science Achievement and Analytical Thinking Ability Using a 5Es Learning Cycle Model (5Es) and a Traditional Teaching Method**. Master of Education, Srinakarinwirot University.