Development of Learning Skills by Using a Computer Assisted Instruction on Problem Solving with Equations to Enhance Critical Thinking Skills of the Fifth Grade Students

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Abstract. The purpose of this study was to develop a computer assisted instruction about problem solving with equations to enhance critical thinking skills of the fifth grade students. Two phases were undertaken in the study. The first phase aimed to develop and monitor the quality of the CAI in which five experts on design and CAI were the main group to evaluate it. The second was to test and evaluate the CAI in which 30 fifth grade students within Bankotabaru School in Yala province were the main participants. The data collected within the first academic term of 2017 in Thailand were analysed using descriptive statistics, such as percentages, means, standard deviations, and t-test.

The results were that the CAI aiming to enhance critical thinking skills of the students were divided into 3 parts; 1) an introduction; 2) teaching processes; and 3) an evaluation. There was a higher percentage of critical thinking skills of the participants in association with before and after the use of the CAI at 52.18 and 80.41 with the difference value of 28.23 and the statistical significance of 0.05 level.

1. Introduction

It is expected that the emphasis of the quality of education is on learners who have acquired the 21st century learning skills: namely creativity and innovation, critical thinking and problem solving, communication and collaboration. However, such skills are still lacking among many Thai students, especially critical thinking skills. Standard school assessment results reported that most of such Thai students still remain on a low level of thinking. This low level was in contrast with individuals who have high levels of critical thinking in that they can demonstrate analytical thinking, synthesis and evaluation, problem solving, and critical thinking [1,2,3]. These thinking processes are considered really necessary for learners of all levels because they are synthesised through thoughtful processes in which empirical information is taken into account and that the individuals can apply into several situations in their lives. Therefore, it is particularly vital to consider that students should be equipped with the skills necessary to live within this increasingly fast-paced society. [4,5]

Based on the scenarios described above, it is crucial to promote and accelerate students' development of the twenty-first century thinking skills by encouraging scholars in education, media and development to carry out research into cognitive development in students, that is, media or an innovation to be used as a guideline for students' learning management.

In this case, a computer-assisted instruction (CAI) could be created to solve such problems and improve performances of teaching. Entering the 21st century, several countries have put an emphasis on the use of information technology as a tool for increasing the ability of competitiveness and service as well as being used as a tool for national innovation development in all sectors. This also includes raising the quality of education that focuses on the development of individuals to ensure that they have abilities to demonstrate the use of technology effectively. This includes living skills, literacy, numeracy, and working skills which critical thinking, creativity, teamwork, communication, and ICT literacy are take into account in order to promote competitiveness which result in developing the manpower in response to rapid changes in a globalised labour market.

Regarding the rationale of the study and the problems as stated above, the researchers intended to develop a CAI on problem solving with equations to enhance critical thinking skills of the fifth grade students

2. Objectives

The objectives of the study were to:
1. develop and examine the quality of the CAI lesson;
2. study the results of using the CAI lesson by looking at critical thinking skills of the fifth grade students and an evaluation of students' critical thinking skills before and after the use of the CAI lesson.

3. Relevant theories and Conceptual framework

3.1 Relevant theories

The relevant concepts and theories are summarised as follows:

- Gagne's learning theory: main learning contents should be in sequential order, ranging from easy to difficult and focusing on achieving satisfactory learning outcomes. [6]
- Ausubel's theory of meaningful verbal learning: main learning contents should be most pertinent with day-to-day activities of learners. [7]
- Bruner's scaffolding theory: main learning contents should enhance learners to develop their skills from simple to complex. [8]
- The principles behind the process of developing a computer assisted instruction program using the ADDIE model: main learning contents should be examined according to analysis, design, development, implementation and evaluation. [9]
- Critical thinking theories aim to develop thinking abilities of learners by using the principle of CAI to enable them to and show their own ideas through learning and practical skills. [10]

3.2 Conceptual Framework

Therefore, the researchers set a conceptual framework for this current study as seen in figure 1.

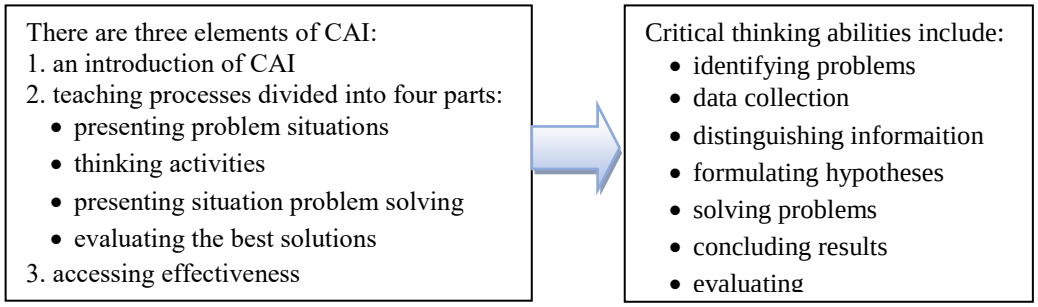

Figure 1 Conceptual Framework

4. Methodology

The study was divided into 2 Phases.

Phase 1 Creating a CAI lesson and checking on its quality of the CAI lesson to enhance students' critical thinking

This part was divided into two sub-steps:

- Step 1 the researchers gained background knowledge and studied concepts, theories and relevant documents about designing and developing a CAI lesson to enhance critical skills of the fifth grade students
- Step 2 the experts examined the quality of a CAI lesson by using: 1) an analysis form about the content of the study document and 2) a five-rating scale questionnaire.

Data collection

1. The researchers brought together the content, concepts, theories and related research;then read , analysed, systhesised, summarised and noted in a content analysis form designed by the researchers.
2. The researchers took advice form 5 experts. There were one content expert, two CAI design and development experts, and two experts in critical thinking, all of whom were responsible for verifying the quality of the CAI lesson.

Data analysis

1. The researchers analysed, synthesised and summaried the main points and then categorised them according to the relavent copcepts and theories. Then, the researchers created a list of importatn contentused for .designing the CAI lesson
2. The researchers analysed the data derived from the evaluation forms about the CAI lesson by comparing average and standard deviation

Phase 2 Testing and evaluating the CAI lesson to enhance*the students*critical skills '

Population and samples

The population for this stage was the fifth grade students who studied in the first semester of academic year 2017 within Yala Primary Educational Service Area Office One at the time when the data collection took place.

30 fifth grade students, who were studying in grade five (referred to Thailand education system), in the first semester of academic year 2017 at Bankotabaru School within Yala Primary Educational Service Area Office One, were selected to be the participants of the study.

Research instruments

There were two research instruments used in the second phase of the study:

1. A CAI lesson about problem solving with equations aiming to enhance critical thinking skills of the fifth grade students consisted of three importantparts : 1) lesson introduction ; 2) teaching processes (problem statements , activi ties for critical thinkingpractices, result presentations and an evaluation of thought processes); and 3(an evaluation in which the CAI lesson was evaluated by the experts inthe lesson content, critical thinking and CAI design and development. In this respect, the experts stated that the CAI lesson was appropriate to be used for promoting the fifth grade students' critical thinking skills.
2. A test for the participated students including pre and post tests. The test contained questions about problem situations in various issues and a multiple-choice section in which one score was given if a participant answered correctly. However, there were no scores given to those whose answers were incorrect in the total of 20 items. The difficulty level of the test was between .28 and .78, the classification power was between .20 and .66 and the confidence level was 0.83.

Data collection
The researchers collected the data through a quasi-experiment which used one group pretest-posttest design [11] as follows:
1. the samples were 30 fifth grade students who were studying in grade five in the first semester of academic year 2017 at Bankotabaru School within Yala Primary Educational Service Area Office One.
2. the experiment was carried out by
   2.1 allowing the participants to do a pre test first; and
   2.2 allowind them to do a post test later.

Data analysis
The researchers aimed to:
1. examine critical thinking skills of the students by looking at the scores of pre and post tests of the students in which percentages and comparative results were used; and
2. examine as well as evaluate the results of using the CAI by comparing the scores of pre and post tests completed by the participants in which t-test was employed.

5. Results
The findings discussed in this section are based on the research aims as follows:

5.1 Research aim one: to develop and examine the quality of a CAI on problem solving with equations to enhance critical thinking skills of the fifth grade students.

- Results of CAI development

For this current study, the knowledge used to design and develop the CAI was gathered from relevant textbooks and research papers in which Adobe Flash CS6, Adobe Photoshop CS6 and Adobe illustrator CS6, Adobe Premier pro, Xara 3D maker, Cool Edit Pro and Microsoft Word 2010 were employed as the main tools to develop the CAI. Developing according to storyboard design, the CAI looked like a multimedia which contains texts, pictures, graphics, graphic animation, videos, sounds and sound effects, all of which made the lesson interesting. The CAI contains three elements as follows:

Element one: an introduction of the CAI is used to present the lesson titles and give suggestions to users on how to use the lesson in which they are required to understand it prior to the use.

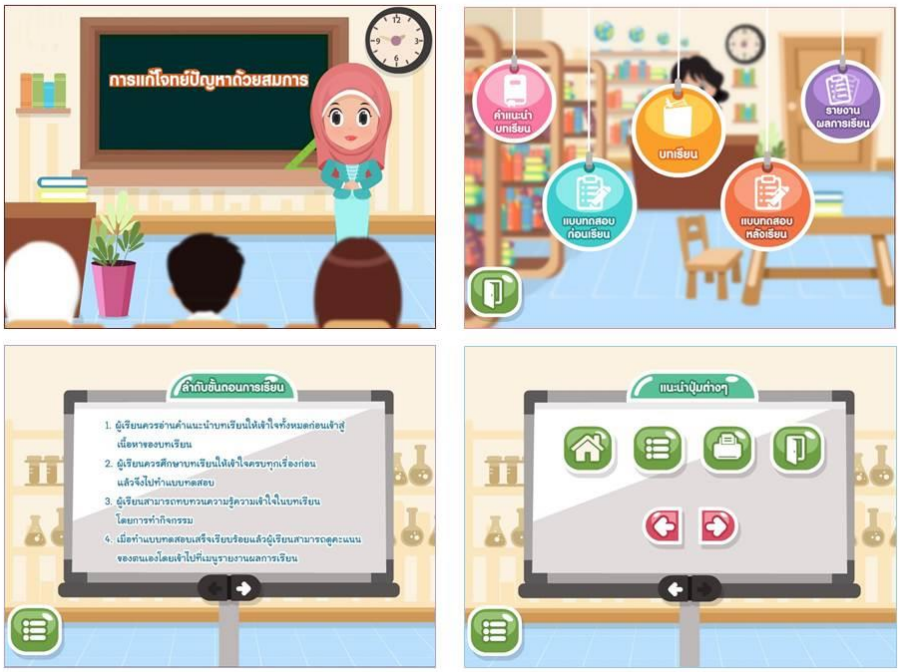

Figure 2 the introductory part of the CAI

Element two: teaching processes which consist of four steps: presenting the situation; individual thinking activities; result presentation; and evaluating the thinking process

Presenting the situation

Individual thinking activities and result presentation

Evaluating the thinking process

Figure 3 examples of the teaching steps

Element three: an evaluation is an activity in part of a post test which students do after they have learned the lesson.

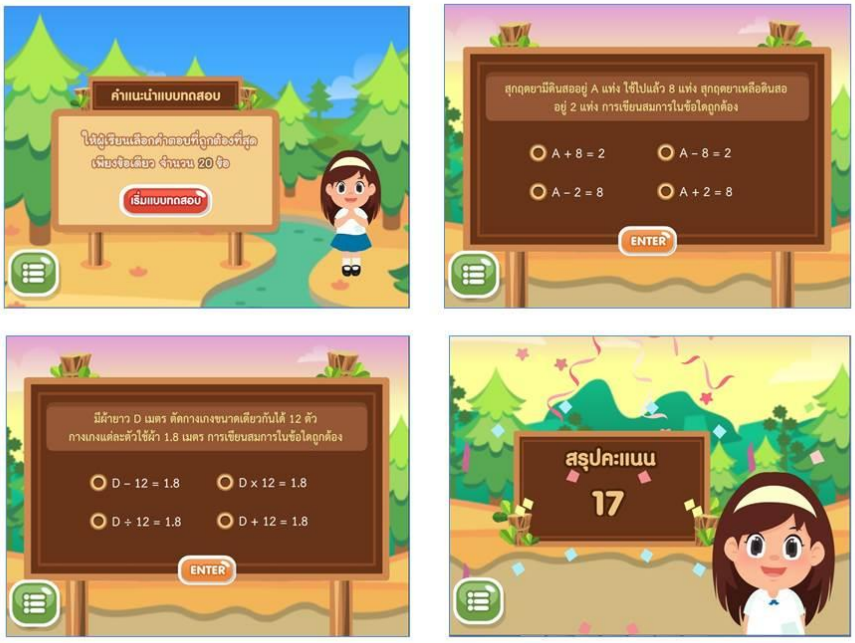

Figure 4: samples of the evaluation results

- Results of the quality examination of the CAI

The CAI was examined by five experts on design and lesson development. The evaluation result is presented in table 1.

Table 1 the mean scores of the evaluation list and opinion levels of the experts on design and lesson development

Eveluation list	**Quality level**		**Result**
	$\bar{X}$	**S.D.**	
Elements of the CAI	4.16	0.63	high
Introduction of the CAI	3.94	0.50	high
Teaching processes	4.22	0.49	high
Evaluation of student results	4.09	0.64	high
Total average	**4.10**	**0.57**	**high**

From Table 1, the mean score of the evaluation of the CAI was at a high level ($\bar{X}$= 4.10, S.D.= 0.57) When considering the mean scores of each aspect from the evaluation list, it is clear that the elements of the CAI ($\bar{X}$= 4.16, S.D.=0.63), the introduction of the CAI ($\bar{X}$= 3.94, S.D.=0.50), teaching processes ($\bar{X}$= 4.22, S.D. = 0.49) and the evaluation of student results ($\bar{X}$= 4.09, S.D.= 0.64) were all at high levels.

5.2 Research aim two: to study the effect on the use of the CAI

- Table 2 shows the percentages of the results of the data analysis regarding before and after the usage of the CAI to see to what extent it enhanced critical thinking skills of the fifth grade students.

Table 2 the result analysis of critical thinking skills of the fifth grade students

List of critical thinking skills	Before using the CAI (percent)	After using the CAI (percent)	Difference value (percent)
Identifying problems	55.36	84.48	29.12
Collecting data	61.85	86.76	24.91
Distinguishing informaition	56.52	82.4	25.88
Formulating hypothesis	54.38	78.2	23.82
Solving problems	56.42	79.6	23.18
Concluding results	42.06	76.88	34.82
Evaluating	38.68	74.54	35.86
Total average	52.18	80.41	28.23

According to Table 2, prior to using the CAI, the fifth grade students showed their critical thinking skills at 52.18 percent. However, after the use, they demonstrated their critical thinking skills at 80.41 percent with the difference value at 28.23 percent.

- Table 3 shows the comparative results of critical thinking skills scores of the fifth grade students before and after the use of the CAI on problem solving with equations.

Table 3 the comparative results of critical thinking skills scores of the fifth grade students before and after the use of the CAI

Samples	No. of learners	Total scores	$\bar{X}$	S.D.	t
Before using the CAI	30	20	11.59	1.70	
After using the CAI	30	20	17.23	0.87	12.56*

P > .05

Based on Table 3, the mean and standard deviation scores of before the use of the CAI were at 11.59 and 1.70, respectively. However, after the usage, the mean and SD scores were 17.23 and 0.87, respectively. Regarding the t-statistics of 12.56, it shows that the students had higher critical thinking skills after taking the CAI than before the use of it, with statistical significance at 0.05 level.

6. Discussion

From the research findings, there are two key issues to be discussed.

6.1 Regarding the development of the CAI lesson on problem solving with equations for enhancing critical thinking skills of the fifth grade students, the experts on design and computer-based lessons stated that the CAI lesson was very well applicable. It was educationally innovative and also popularly used in teaching and learning at present. In this respect, the researchers conducted the study based on the use of relevant textbooks and research studies and utilised the knowledge gained to design and develop the CAI lesson according to the systematic methodology. [9,10] Consequently, it became user-friendly and appeared to be beautiful and attractive-looking. It also encouraged students to be

more engaged in learning the lesson and its activities. Furthermore, the CAI lesson was also evaluated by the experts on the mathematics subject of problem solving with equations, the experts in critical thinking, and experts in CAI design and development. As the result, the quality of the CAI lesson was at the acceptable level. Moreover, the researchers also tried to find efficiency by using some other examples that matched the CAI lesson. In each time of trial, the researchers noticed learners' behaviour and then corrected the mistakes; as a result, the lesson appeared to be effective and helped learners pass all the learning processes and their final assessment. This was consistent with [12] stating that piloting of innovative procedures was strongly recommended for a researcher so that the study and the evaluation of the experiment could become rigorous.

6.2 The study found that the average score of the fifth grade students before the use of the CAI lesson was 11.59, while the mean score of the post test and t-statistics were 17.23 and 12.56, respectively. This shows that the learning ability of the students was improved after the use of the CAI lesson, with the statistical significance of 0.05. However, because the development of the CAI lesson has proceeded according to the sequence of principles, concepts, theories, aims, organising teaching and learning activities that helped the teaching and learning processes to be efficient and effective, and the development of tools used in teaching and learning activities and evaluation, it then increased the integrity of the teaching process. This as a result helps enhance critical thinking skills of the students appropriately. Furthermore, there needs to be criteria set for achieving them. We argue that teaching and learning activities should not be only student-centred, but also linked to one another, such as informing learning objectives and preparing various problem situations in accordance with students' daily practices. These would help students practise their critical thinking skills and supports scholars in this field to set out practical guidelines for better results. [4,7] Moreover, teaching and learning should start from the very basic to gradually advanced level so that it allows ample time for students to practise their ability to think critically. [6] In doing so, such students who have different learning experiences and background knowledge would appear to be motivated as they are able to build up the relationship between their previous and current knowledge. [8] Allowing the students to think systematically and independently would enable them to achieve their individual learning goals. With respects to the attractive CAI design, it would also stimulate students' interest in learning their lessons and activities more engagingly. Hence, it can strive to improve their learning noticeably. [13]

7. Suggestions

7.1 general suggestions

- The CAI aimed to enhance critical thinking skill of the students through the lesson on problem solving with equations in which the researchers believed it was suitable and applicable to the fifth grade students or other students at higher levels. This is because the contents, as well as teaching activities in the lesson were designed to suit the abilities of the students at such levels.
- To ensure better learning, students should be given the lesson guide so that they could be familiar with various symbols and command buttons prior to taking the lesson.
- Regarding students with learning differences, it is important to state that this CAI should not be restricted to time as different individuals have different levels of learning abilities. In this case, a teacher should allow students to learn it regardless of the time limit until they have understood the lesson.
- Despite the nature of web-based learning in which learners study autonomously, a teacher still plays a vital role in providing advice and helping learners in case problems about computers and programs may occur, for instance.

7.2 Suggestions for further research

- Researchers should develop a CAI tool which enhances critical thinking skills at a higher level, such as CAI s for lower and upper secondary school students.
- Researchers should also develop a CAI tool which enhances other aspects of the students' abilities, such as moral issues and desirable characteristics of learners.
- Researchers should conduct a comparative study of CAI to find other effective ways of enhancing students' critical thinking skills.

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