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Investigating Learning Achievements of Thai High School Students in a Sequences and Series Lesson Delivered on CAI-Based Materials*

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The current experimental research aims to investigate students' learning outcomes in classes in which the interactive CAI (computer-assisted instruction)-based materials were implemented. It also aims to compare the learning outcomes of the students based on regions in which their school is located. The participants were 326 Matthayom-4 students of the academic year 2010 from nine pre-specified schools of four regions. The researchers spent total 24 hours experimenting and collecting data at each school. There are three research instruments. The first one is CAI-based lessons in sequences and series. The efficiency of the CAI-based activities is 70.8/86.93. The second instrument is 30-item pre-test and 30-item post-test of learning performance with between 0.2 and 0.8 difficulty values, 0.55 average of total difficulty, 0.43 power of discriminant and 0.95 reliability of co-efficiency. The third instrument is 16-item one to five rating scale questionnaire concerning student satisfaction, with 0.83 reliability co-efficiency alpha of all items. The researchers found that, after the scores from the pre-test and post-test were compared, the students got better scores in the post-test, with statistical significances of 0.05. This implies that the CAI-based materials lead to the students' better learning outcomes. After the materials were implemented in all regions, and then compared, the researchers found that the students from central Thailand got higher scores than those from any other region. The students believed that, the researchers concluded, CAI-based materials aided their comprehension of the lesson, created their motivation to learn and complimented the content; that the animation was well-designed, understandable and friendly-user; and that the activities were interactive and appropriate.

Keywords: sequences and series, lesson delivered, Thai high school, learning achievement

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Introduction

According to Thailand's National Education Act of 2010 (Volume 3), dated July 12, 2010, education is defined as the learning process for personal and social development through transferring of knowledge; practice; training; transmission of culture; enhancement of academic progress; and building a body of knowledge by creating a learning environment and learning society and the availability of factors conductive to continuous lifelong learning. Therefore, education, regardless of academic areas, should enable a person to fully develop in every possible way. Mathematics is a subject that mainly aims to help students reasonably create and develop their creative thinking capacity, promote analysis through the nature of reality and logics. In Thailand, mathematics is taught at all educational levels. This study focuses on the last three years at a secondary school level (or a high school level) which prepares students for their higher education—an institutional source of trained and educated personnel for the nation. As a result, a sequences and series lesson at a high school level is important fundamentals to advanced mathematics in higher education. Chungdang, Singhaprink, Pongpullponsak, Tantipisankul, and Praekhaow (2009) found that a lecture on and the exemplification in a sequences and series lesson remained problematic as the two techniques did not satisfactorily enable the students to comprehend the relevant concepts and to develop their thinking skills. This results in students' failure in advanced mathematics in higher education. So far, many studies have investigated the effectiveness of CAI (computer-assisted instruction). For instance, Hansen (1968) and Sampson (1986) explored the use of CAI in support of instructional processes and psychotherapeutic processes. Skinner (1990) wrote that, although the efficacy of CBI (computer-based instruction) as compared with traditional instruction has been well documented, efforts to determine specific setting, instructional design and learner variables which maximize CBI effectiveness is of fairly recent vintage. His project showed the effects of CBI on the achievement of college students as a function of achievement status and mode of CBI instruction (i.e., CBI tutorials optional or mandatory) in the context of a course taught under a personalized system of instruction format. A unique aspect of the study was the use of a single subject (i.e., alternating treatments). The results indicated that low achieving students benefited more from CBI than high achievers. Carter (2004) studied an analysis and comparison of the effects of CAI versus traditional lecture instruction on students' attitudes and achievement in a college remedial mathematics course. He referred in his study that much of the research on remedial mathematics instructions showed that it was only moderately successful in improving the students' achievement in mathematics or their attitudes towards mathematics. It was found from his study that there were statistically significant achievement gains within the treatment and control groups as a result of instruction that each group received. However, there was no statistically significant difference in achievement gains between the two groups when the study ended. Also, the results on the attitude assessment showed no statistically significant difference within each group after the study was completed. Liao (2004) also performed a meta-analysis to synthesize existing research comparing the effects of CAI versus traditional instruction on students' achievement in Taiwan. The results from his studies suggested that the effects of CAI in instruction were positive over traditional instruction. Seo and Bryant (2009), who studied the effects of CAI on the mathematics performance of students with learning disabilities, found that those CAI studies did not show conclusive effectiveness with relatively large effect sizes. The methodological problems in the CAI studies limited an accurate validation of the CAI effectiveness.

After having read relevant research, the researchers are convinced that CAI-based materials are more

effective than traditional lectures. Therefore, they designed the CAI-based materials that could interact with students, with the hope that students could fully academically develop themselves to meet the requirements set by the National Education Act. Specifically, they designed interactive CAI-based materials that could be used in a sequences and series lesson offered in the last three years at a secondary school level. The researchers conducted an experimental study to be administered in class attended by above-average and below-average Matthayom-4 students of the target schools. The study positively expected that implementation of CAI-based activities would result in equality in Thai education firstly and significantly improve students' learning outcomes in the sequences and series lesson secondly.

Research Methodology and Data Analysis

The population in this study were Matthayom-4 students of the academic year 2011 from 2,361 schools located in four regions of Thailand (i.e., Northern, Northeastern, Southern and Central).

The samples were Matthayom-4 students of the academic year 2010 from nine pre-specified schools located in four regions of Thailand. That is, the samples were from two different schools located in two Northern provinces, three different schools in three Northeastern provinces, two different schools in two Southern provinces and two schools in Bangkok. There were total nine schools from eight provinces. The samples which were randomly chosen from these nine schools were 326 above-average and below-average students. The number of students from each school is presented in Table 1.

Table 1

The Number of Sample Students From Each School

School	Province	Number of students
1. Nareetat	Prae	39
2. Boonyawartwitthayalai	Lumpang	23
3. Khu-kan	Srisaket	39
4. Chareomprakiat Somdejprasrinakharin	Roi-ait	40
5. Nawhawitthakhom	Nakhonpranom	59
6. Triamudomsuksa Parktai	Nakhonsrithammarat	30
7. Suratthanee	Suratthanee	30
8. Bangpakokwitthayakom	Bangkok	36
9. Isalam Colledge of Thailand	Bangkok	30

Scope of the Research

The current experimental study explains the students' learning achievement in a sequences and series lesson supported by CAI. The subjects were from high schools located in different regions of Thailand. Variables include learning achievement, CAI-based materials and student satisfaction of the CAI-based materials.

Research Instruments

Interactive CAI-based materials were used in the sequences and series lesson; and the efficiency of the materials was between 70.80 and 86.93. The materials included learning materials, drilling and exams of each subtopic. There were animated characters used to introduce the lesson. Motion pictures were designed to display samples. Additional explanations were provided to help students understand some necessary concepts they needed in order to complete the tasks. Besides, there were games that relaxed and calmed down the students. This is presented in Figures 1, 2 and 3.

Figure 1. Table of content and Website map.

Figure 2. Webpage introducing to sequences lesson.

Figure 3. Drilling practices provided by the CAI-based site.

There were 30 pre-test questions and 30 post-test questions, difficulty index of which fell between 0.2 and 0.8, average difficulty of which in all items was 0.55, the power discriminance of which was 0.43 and the reliability co-efficiency alpha of which, following Cronbach's co-efficiency alpha formula, was 0.95 (Reynolds, Livingston, & Willson, 2010).

Questionnaires concerning student satisfaction included eight questions on the presentation pattern and another eight on program techniques. These questionnaires were adapted from the one by Chundang and Wannachot (2007), which was used by researchers to explore student satisfaction of CAI-based materials in a basic mathematics course. The initially-designed questionnaire yields 0.83 co-efficiency alpha.

Research Procedures

The procedures of this study include:

(1) The researchers pre-specified schools and provinces in regions of Thailand;

(2) They randomly sampled students from the pre-specified schools. Students whose GPA is between 2.75 and 3.25 are considered above-average; while those students whose GPA is between 2.00 and 2.50 are considered below-average;

(3) They administered a two-hour pre-test and a two-hour post-test. The two tests were interpolated by 20-hour CAI-based activities[1];

(4) All pre-specified students were asked to complete the questionnaires.

Data Analysis

The date analyses are as follows:

(1) Comparing the pre-specified students' learning achievement before and after the materials is implemented. In the current study, the students' learning achievement was analyzed according to the following three aspects. For the first analysis, the researchers compared their pre-test and post-test scores regardless of their performance and the subtopics. For the second analysis, they still compared the two tests after grouping the students according to their academic record (i.e., either they are below- or above- average). For the last analysis, they still compared the two tests in each sub-topic (i.e., sequences and series). The pre-specified students' learning achievement can be measured by the materials content, following Wilcoxon Signed Ranks Test (Gibbons & Chakraborti, 2011);

(2) Finding the effectiveness index of the learning progress, following a method of Goodman, Fletcher, and Schneider (1980);

(3) Following Kruskal-Willis one-way ANOVA (analysis of variance) test, comparing the student's knowledge based on their regions before and after the materials is implemented. If a comparison of each pair of regions yields 0.05 significant differences, the researchers would further analyze such pair using "a multiple comparison";

(4) Analyzing possible problems in implementing CAI.

Results

The findings of the current research reveal two aspects that are worth discussing: learning achievement of students participating in a CAI-based lesson and student satisfaction of that lesson.

[1] Normally, it takes approximately 40 hours to cover the same content in Matthayom-5 and Matthayom-6 levels.

Learning Achievement of Students Participating in CAI-Based Activities

The comparison of the students' pre-test and post-test scores and the effectiveness index of the progress of CAI-enhanced learning, based on Wilcoxon Signed Ranks Test, can be illustrated in Tables 2, 3 and 4.

Table 2

Comparison of Pre-test Scores and Post-test Scores of Above-Average Students

Region	Average score		E.I. (effectiveness index)	Mean rank (post-pre)		*Z*
	Pre	Post		Negative ranks	Positive ranks	
North	20.06	33.77	0.34	7.80	16.91	-4.42*
Northeast	16.56	26.15	0.22	16.81	37.59	-5.67*
South	20.93	29.90	0.23	12.75	25.70	-4.26*
Central	16.71	43.29	0.61	0	17.50	-5.91*
All regions	18.08	31.90	0.32	33.81	86.94	-9.98*

Notes. *Z* is *Z* Test of Wilcoxon that is based on negative rank; * represents the significant difference which is 0.05; the full score of the post-test and pre-test is 60 each.

Table 3

Comparison of Pre-test Scores and Post-test Scores of Below-Average Students

Region	Average score		E.I. (effectiveness index)	Mean rank (post-pre)		*Z*
	Pre	Post		Negative ranks	Positive ranks	
North	18.74	27.94	0.22	13.0	15.15	-4.15*
Northeast	15.17	24.34	0.20	11.20	37.48	-6.35*
South	17.00	24.03	0.16	10.25	14.09	-3.42*
Central	12.53	30.28	0.37	1	17.00	-4.92*
All regions	15.66	26.15	0.24	31.24	82.72	-9.79*

Notes. *Z* is *Z* Test of Wilcoxon that is based on negative rank; * represents the significant difference which is 0.05; the full score of the post-test and pre-test is 60 each.

Table 4

Comparison of Pre-test Scores and Post-test Scores of Mixed Ability Students

Region	Average score		E.I. (effectiveness index)	Mean rank (post-pre)		*Z*
	Pre	Post		Negative ranks	Positive ranks	
North	19.40	30.85	0.28	18.40	31.60	-6.06*
Northeast	15.86	25.17	0.21	27.37	74.76	-8.54*
South	19.03	27.07	0.20	27.75	29.31	-5.45*
Central	14.68	37.24	0.50	1	34.40	-7.06*
Total	16.88	29.04	0.28	63.40	169.30	-13.98*

Notes. *Z* is *Z* Test of Wilcoxon that is based on negative rank; * represents the significant difference which is 0.05; the full score of the post-test and pre-test is 60 each.

The result from testing reveals that the post-test scores of students from all chosen regions are significantly higher than their pre-test with 0.05 significant differences. This means that the designed interactive CAI-based materials effectively improved learning outcomes of the students. The learning improvement rate of the above-average and below-average students and a combination of the two levels are 23.03%, 17.48% and 20.47%, respectively. The effectiveness index of the CAI-enhanced learning progress reveals that the students from central Thailand got the highest scores. The E.I. of the three groups of students, according to their performance is 61, 37 and 50, respectively. The findings point out that learning effectiveness of the students

from central Thailand is very positively satisfactorily increased.

The comparison of the pre-test and post-test and the effectiveness index of the CAI-enhanced learning process of the students in each subtopic, using Wilcoxon Signed Rank Test, are presented in Tables 5 and 6.

Table 5

Comparison of the Students' Pre-test and Post-test Scores in the Sequences Lesson

Region	Average score		E.I. (effectiveness index)	Mean rank (post-pre)		*Z*
	Pre	Post		Negative ranks	Positive ranks	
North	11.35	18.02	0.36	20.89	31.08	-5.17*
Northeast	9.07	13.33	0.20	44.55	71.20	-6.72*
South	10.98	16.22	0.28	20.50	31.61	-4.88*
Central	8.89	21.50	0.60	3.50	33.44	-6.91*
All regions	9.82	16.40	0.33	89.64	168.22	-12.28*

Notes. *Z* stands for the *Z* Test of Wilcoxon that is based on negative ranks; * represents the significant difference which is 0.05; the full score of the pre-test and post-test is 30 each.

Table 6

Comparison of the Students' Pre-test Scores and Post-test Scores in the Series Lesson

Region	Average score		E.I. (effectiveness index)	Mean rank (post-pre)		*Z*
	Pre	Post		Negative ranks	Positive ranks	
North	8.05	12.84	0.22	17.58	29.81	-5.66*
Northeast	6.79	11.84	0.22	31.97	71.77	-8.55*
South	8.05	10.85	0.13	19.75	28.69	-4.60*
Central	5.79	15.74	0.41	2.50	33.48	-7.01*
All regions	7.06	12.64	0.24	70.88	163.99	-13.50*

Notes. *Z* stands for the *Z* Test of Wilcoxon that is based on negative ranks; * represents the significant difference which is 0.05; the full score of the pre-test and post-test is 30 each.

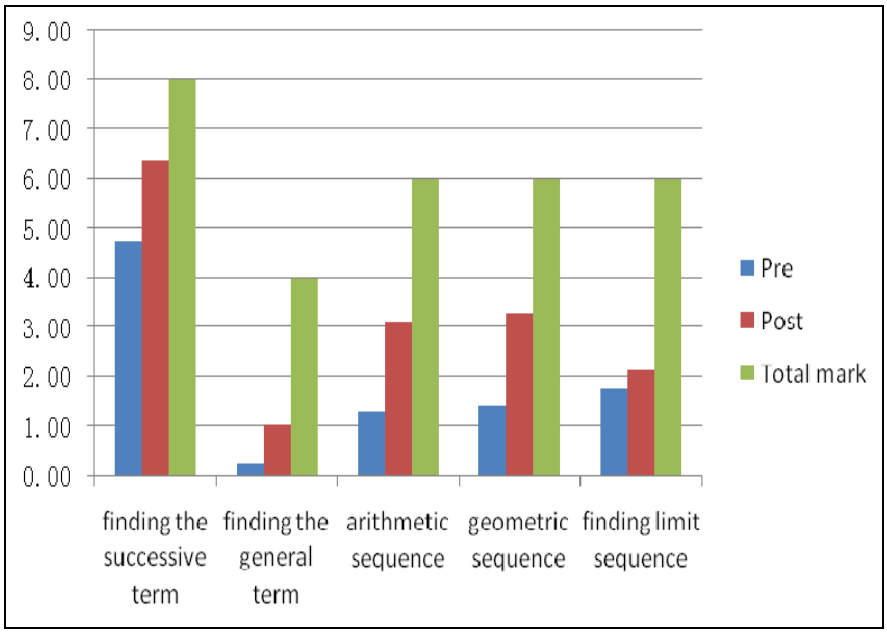

Figure 4. Average score of the pre-test and post-test of each subtopic under sequences.

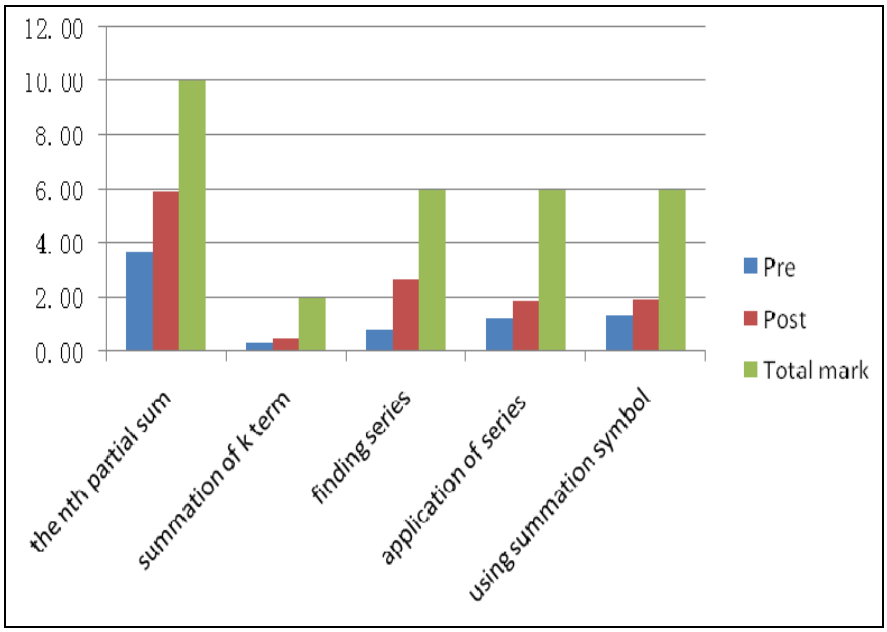

Figure 5. The average score of the pre-test and post-test of each subtopic under series.

The students from all selected regions received better scores in both the sequences lesson and the series lesson with 0.05 statistical significance. The data implies that the designed interactive CAI-based materials result in the students' better learning outcomes. The learning performance in both the sequences lesson and the series lesson is increased 21.97% and 19.33%, respectively. The effectiveness index of the progress of CAI-based learning reveals that the E.I. of the students from central Thailand is the highest in both the sequences lesson and the series lesson. That is, the E.I. of the students in the sequences lesson and the series lesson is 60 and 41, respectively. The average comparison of the pre-test and post-test of the sequences lesson, the lesson which consists of finding the successive term, finding the general term, arithmetic sequence, geometric sequence and finding limit of sequence, is displayed in Figure 4. That of the series lesson, the lesson which consists of the *n*th partial sum, summation of *k* term, finding series, application of series and using summation symbol, is illustrated in Figure 5. It appears that all students got better scores in all subtopics. However, finding the successive term of sequence is the only subtopic whose effectiveness index is satisfactorily with 50.61%.

A comparison of the students' background knowledge, based on Kruskal-Wallis one-way ANOVA test, before the interactive CAI-based materials were implemented in class is presented in Tables 7 and 8.

Table 7

Comparison of the Students' Background Knowledge

Region	N	Median	Mean rank	*Z*	Chi-square
North	66	2	119.06	4.29	28.86*
Northeast	62	18	187.14	2.19	
South	138	16	157.68	-0.95	
Central	60	20	201.32	3.44	
Total	326		163.50		

Note. * represents the significant difference which is 0.05. *Z* stands for the Kruskal-Wallis one-way ANOVA.

Statistically, Table 7 demonstrates that the mean rank of the students' background knowledge from all regions, before the interactive CAI-based materials were implemented, is different at the statistical significance level of 0.05. This means that the students from the selected schools from the Northern, Northeastern, Central and Southern Thailand had relatively different background knowledge of sequences and series. The analysis of multiple comparison of mean rank of each pair of regions discovers that the students had different background knowledge of sequences and series before using the interactive CAI-based materials again, at the statistical significance level of 0.05.

Table 8

Multiple Comparison of Students' Background Knowledge

Region	Central	Northeast	North	South
Central	0			
Northeast	38.62*	0		
North	68.08*	29.46*	0	
South	82.26 *	43.64*	4.18*	0

Note. * represents the significant difference which is 0.05.

A comparison of knowledge the students gained after the interactive CAI-based materials were implemented, based on Kruskal-Wallis one-way ANOVA test, is illustrated in Tables 9 and 10.

Table 9 points out that the average knowledge of the students from each region after the interactive CAI-based materials were implemented is different at the statistical significance level of 0.05. This suggests that the students from the selected schools in Northern, Northeastern, Central and Southern Thailand differently developed their knowledge of sequences and series after participating in the interactive CAI-based materials. The analysis of multiple comparison of each pair of regions, as shown in Table 10, implies that the students' background knowledge of sequences and series from all regions is different at the statistical significance level of 0.05.

Table 9

A Comparison of Knowledge the Students Gained After the Designed Materials Were Used

Region	*N*	Median	Mean Rank	*Z*	Chi-square
North	66	32.5	237.9	7.19	66.53*
Northeast	62	30.0	182.44	1.76	
South	138	25.0	127.08	-5.98	
Central	60	26.5	145.78	-1.61	
Total	326		163.50		

Note. * represents the significant difference which is 0.05. *Z* stands for the Kruskal-Wallis one-way ANOVA.

Table 10

Multiple Comparison Knowledge the Students Gained After the Designed Materials Were Used

Region	Northeast	South	North	Central
Northeast	0			
South	18.7*	0		
North	55.36*	36.66*	0	
Central	110.82*	92.12*	55.46*	0

Note. * represents the significant difference which is 0.05.

The comparison of the students' pre-test scores and post-test scores indicates that it is impossible to design the materials that suit the students from all the regions. That is, the interactive CAI-based materials should be tailored to fit students' different basic knowledge which greatly varies.

Student Satisfaction of the CAI-Based Materials Used in a Sequences and Series Lesson

The criterion for interpretating student satisfaction of the CAI-based materials completed by 326 Matthayom-4 students from the four regions followed John's (1981) criteria, which is shown as follows: Rank 1.00-1.49 means "Least satisfied"; 1.50-2.49 means "Somewhat satisfied"; 2.50-3.49 means "Fairly satisfied"; 3.50-4.49 means "Very satisfied"; and 4.50-5.00 means "Most satisfied".

The analysis reveals that the sample students were very satisfied with the CAI-based materials, except item 2 under the satisfaction of the material and material presentation. These two findings are displayed in Table 11.

Table 11

Level of Student Satisfaction of CAI

Satisfaction of the material and material presentation	Sum	S.E.	Level
1. You think that the materials are useful.	4.36	0.04	very
2. Before using the materials, you understood the lesson.	3.28	0.05	fairly
3. The contents are well ordered.	4.02	0.04	very
4. The contents of the materials are clear and appropriate.	3.98	0.04	very
5. The materials stimulated help you understand learning.	3.92	0.05	very
6. The knowledge you gain from using the materials is helpful for your future education.	4.13	0.04	very
7. You can learn from the materials by yourself.	3.87	0.05	very
8. After using the materials, you understand the lesson better.	3.87	0.04	very
Satisfaction of program techniques	Sum	S.E.	Level
1. Pattern and organization of pictures and texts are appropriate.	4.13	0.04	very
2. The use of pictures is appropriate.	4.00	0.04	very
3. Interactive gap filling activities are appropriate.	4.02	0.04	very
4. Drag and drop activities are appropriate.	4.27	0.16	very
5. Sentence or word filling activities are appropriate.	4.09	0.04	very
6. Sentence completion activities are appropriate.	4.07	0.04	very
7. Colors together with the materials are appropriate.	4.15	0.04	very
8. Voices accompanying the materials are appropriate.	3.84	0.06	very

Note. S.E. is the standard error.

Conclusions and Comments

This study shows that the designed CAI-based materials were effective. When examining the 326 students' learning outcomes, the researchers found that the students who were in the CAI-based classes studied better. Their scores obtained after participating in the CAI-based activities were much better than those obtained before. The sample students whose performances were above the average and below the average performed better after participating in the CAI-based activities. When examining their learning outcomes from the sequences and series lesson, the researchers found that those who participated in the CAI-based materials were very satisfied with the presentation and the program techniques. In brief, the interactive CAI-based materials used in a sequences and series lesson were effective. There are comments, however. Although the sample students' performances were much better, the analysis of learning effectiveness index reveals that the

scores of students only from central Thailand were more than 50%. A close analysis of the students' performance in the sub-topics (i.e., sequences and series) shows that the effectiveness index of sequence is 60%, while that in the series lesson is less than 50% with the highest 41% of students from Central Thailand. This implies that learning outcomes of students from all regions, except Central Thailand, remain low. When comparing their basic knowledge obtained before and after attending the CAI-based lesson, the researcher found that their basic knowledge was different with 0.05 significant differences. Such significant difference was not expected by the researchers because they highly anticipated that, after the students studied the CAI-based materials, their learning outcomes would not be greatly different or the significant differences would be less than 0.05. The reasons are presented as follows. First, the sample students were from Matthayom-4 level, while in reality, the subject sequences and series is introduced to Matthayom-5 and Matthayom-6 students. In addition, it normally takes 40 hours to introduce the subject matter as planned in the National Education Act, while the researchers limited only to 20 hours (or 50% less). This may have resulted in insufficient amount of time for the students to absorb the content and revise the lesson. Another explanation is that instructions in the sequences and series were different in the regions, due to students' performance and ability of learning and control of instructors, which resulted in the students' knowledge. The researchers believe that, if more time permitted, the students' learning outcomes would have significantly high as initially expected. The students could have needed more time to familiarize themselves with the content, practice solving the problems and revise for the tests. Moreover, it is necessary for the experiments that the participants cooperate.

References

Best, J. W. (1981). *Research in education* (4th ed.). Engle Wood Cliffs: Prentice-Hall.

Carter, M. B. (2004). An analysis and comparison of the effects of computer-assisted instruction versus traditional lecture instruction on student attitudes and achievement in a college remedial mathematics course (Doctoral dissertation, University Philadelphia). Retrieved from http://www.dl.cm.org/citation/cfm?id=1037361

Chundang, U., & Wannachot, K. (2007). The satisfaction in using CAI (computer-assisted instruction) for studying basic mathematics subject. *Journal of Education: Faculty of Education: Srinakharinwirot University, 8*(3), 36-43.

Chundang, U., Singhaprink, W., Pongpullponsak, A., Tantipisankul, T., & Praekhaow, P. (2009). Teaching problems and high school students' competency in topics sequences and series (pp. 17-19). *International Conference in Mathematics and Applications, ICMA-MU.*

Gibbons, J. D., & Chakraborti, S. (2011). *Nonparametric statistical inference* (5th ed.). New York: CRC Press.

Goodman, R. I., Fletcher, K. A., & Schneider, E. W. (1980). The effectiveness index as comparative measure in media product evaluation. *Education technology, 20*(9), 30-34.

Hansen, D. (1968). Computer-assisted instruction and the individualization process. *Journal of School Psychology, 6*(3), 77-185.

Liao, Y. C. (2004). Effects of computer-assisted instruction on students' achievement in Taiwan: A meta-analysis. *Computers and Education, 48*(2), 216-233.

Office of the Teacher Civil Service Commission. (2010). *Thailand's National Education Act of 2010*. Ministry of Educational Affair. Retrieved June 1, 2011, from http://www.203.146.15.33/webtcs/

Reynolds, C. R., Livingston, R. B., & Willson, V. (2010). *Measurement and assessment in education*. New Jersey: Pearson Education.

Sampson, Jr., J. P. (1986). The use of computer-assisted instruction in support of psychotherapeutic processes. *Computers in Human Behavior, 2*(1), 1-19.

Seo, Y., & Bryant, D. P. (2009). Analysis of studies of the effects of computer-assisted instruction on the mathematics performance of students with learning disabilities. *Computers and Education, 53*(3), 913-928.

Skinner M. E. (1990). The effects of computer-based instruction on the achievement of college students as a function of achievement status and mode of presentation. *Computers in Human Behavior, 6*(4), 351-360.

Upper Secondary Education Bureau. (2010). *Information about number of secondary school in the year 2010*. Ministry of Educational Affair. Retrieved June 1, 2011, from http://www.secondary.obec.go.th