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The Development of Analytical Skills in Mathematics of Grade 6 Students

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Abstract
This research is aimed at developing analytical skills in mathematics of Grade 6 students and evaluating the results of the development of these analytical skills in the learning of mathematics by integrating collaborative learning and case-based learning in the learning process. This research was conducted in the academic year 2012. The target population group consisted of 61 Grade 6 students at Satit Bilingual School of Rangsit University. The research instruments used in this study were: 1) the mathematics teaching process which integrated collaborative learning and case-based learning, 2) a case-study handbook, 3) mathematics lesson plans, 4) an evaluation form for analytical skills, 5) a mathematics test, and 6) an evaluation form concerning students' attitudes towards the mathematics learning process. The data obtained were analyzed by using mean scores, standard deviation, and percentages. The results of the study were as follows. First, the development of the analytical skills was brought about by integrating collaborative learning and case-based learning in the learning process. This process consisted of the following four stages: a) elicitation of prior knowledge, b) presentations of case studies, c) case analysis through collaborative learning, and d) conclusion and application of the knowledge gained. Second, the average score for analytical skills of the targeted group of students was at a high level, and the development of their analytical skills increased steadily throughout the study. Third, the average score for knowledge of mathematics in the target group of students after the learning process (post-test) was higher than their average score prior to the learning process (pre-test). Last, the average score for attitude toward the mathematics learning process of the target student group was at the highest level.

Keywords: *development of analytical skills, collaborative learning, case-based learning, integration of collaborative learning and case-based learning*

1. Background and Significance

The era of globalization can be considered as a world full of news and information. However, if people are unable to think analytically about the information they have received, the results will be apparent in the decisions they make in their work or in their daily lives. Thus, analytical thinking is a necessary skill in the modern world. Nowadays, teaching how to think has become a topic of interest in countries around the globe, including Thailand. In Thailand, the National Education Act of B.E. 2542 [1999] (revised B.E. 2545 [2002]) established an educational reform process to develop thinking skills as can be seen in Article 24, Paragraph 2, in which decreed that in the management of learning, schools must give students practice in the thinking process. In addition, the development of the thinking process should be evaluated in the quality assurance program of schools and the evaluation provided by the National Education Standard Tests (Susoarat, 2010).

Analytical thinking is an important foundation for learning and living, as it consists of important skills: classification, grouping, error analysis, application, and prediction (Marzano, 2001). In addition, analytical thinking is a skill that everyone can develop (Susoarat, 2010). However, the External Quality Assurance No. 2 of the fiscal years 2006-2008 found that, in its

overview of analytical thinking, the average scores for students all over the country were relatively low (Office of Education Council, 2009).

Mathematics is a subject in which students have to use their thinking skills, and it serves as a foundation for learning other subjects. Thus, mathematics plays a role in the development of thinking among humans. In addition, mathematics helps people to develop into true humans with a balance of body, mind, wisdom, and emotions, so as to enable them to think, solve problems, and live with one another happily (Department of Curriculum and Instruction Development, 2002).

The Ordinary National Educational Testing (O-NET), which measured comprehensive knowledge at the end of the second learning period of Grade 6 students for the academic years 2010-2013 revealed average mathematics scores of 34.85%, 52.40%, 35.77%, and 41.95%, respectively (http://www.niets.or.th/index.php/research_th). From the data above, it can be seen that the average scores for the majority of students did not reach the level of 50%. In addition, Trends in International Mathematics and Science Study: TIMSS 2007 reported that, in Thailand, the average mathematics scores of Thai students were below those of students from almost all neighboring countries, except Indonesia. In addition, the average mathematics score of Thai students was 441 (Office of Education Council, 2009). The results corresponded with that of the Program for International Student Assessment: PISA 2009, which found that the average mathematics score of Thai students was 419 (The Institute for the Promotion of Teaching Science and Technology [IPST], 2011). It was also found that the TIMSS and PISA scores were below world average scores in both projects. This was due to the fact that, in the pedagogy used in the majority of schools, teachers were the ones who passed on knowledge to students, and students played the role of recipients only, without any focus on learning activities (Johnson, 2008).

Having students study or do activities in groups, or at the least in pairs, would cause students to participate in expressing their ideas and finding the flaws in those ideas. In following this method, students would practice their thinking, correct their errors, and develop the ideas gained from feedback that they received (Susoarat, 2010). Johnson and Johnson (1989) stated that collaborative learning was effective in the teaching and learning of mathematics, as it helped stimulate mathematical thinking among learners; it also helped learners to understand the relationships between concepts and processes, and to be able to apply the knowledge gained actively and meaningfully.

The use of collaborative learning enables students to develop the skill of working with others, to become responsible, and to become interdependent; learning through the case method is a way to help learners to get ready to solve problems, practice various learning methods to seek knowledge, become able to connect old and new knowledge or strengthen and widen knowledge, and become able to apply their knowledge in their daily lives (Muulkam, 2002). Learning through the case method is also a way to open up the opportunity for learners to think analytically and to learn others' thinking, as well as to help widen learners' viewpoints (Khammani, 2010). In managing the learning of mathematics, teachers often set problems for students to think about. Many problem sets have the characteristics of case studies. However, in the past, many students

were unable to solve those problem sets, due to the fact that they were not related to the students' daily lives. In addition, those problem sets were not challenging enough to make students think. Thus, creating problem sets which are challenging and interesting is important.

As stated above, to develop analytical skills in learners based on the Basic Education Core Curriculum B.E. 2551 (A.D. 2008), the assessment for education quality, the measurement and evaluation at national level must include matching, classifying, analyzing errors, generalizing, and specifying. This assessment relies on various learning processes, as well as learning management using collaborative learning, suitable for learning mathematics. This collaborative learning should be integrated with a case-study method. This latter introduces the use of case studies which are similar to problem sets in the study of mathematics. This can greatly enhance learners' skills of analytical thinking. For the reasons stated above, the researcher was interested in developing the analytical skills of Grade 6 students in mathematics through the integration of collaborative learning and case-based learning.

2. Research Objectives

The objectives of this research were, as follows.

1) To develop the analytical skills of Grade 6 students in learning mathematics through the integration of collaborative learning and case-based learning.

2) To evaluate the results of the development of the analytical skills of Grade 6 students in learning mathematics through the integration of collaborative learning and case-based learning.

3. Research Methodology

The research methodology includes information regarding the informants and the instruments used in this research.

3.1 Informants

The informants in this research were the target group of the population of 61 Grade 6 students of Satit Bilingual School of Rangsit University, Pathum Thani Province, in the academic year 2012.

3.2 Instruments Used in this Research

The instruments used in this research were the 30 mathematics lesson plans and the case handbook for mathematics, described in more detail below.

3.2.1 *Mathematics Lesson Plans*. There were 30 mathematics lesson plans, following the Basic Education Core Curriculum B.E. 2551 (A.D. 2008) for Grade 6. These plans were used for the 15-week course. There were two classes per week. The total was 30 classes.

Every lesson plan consisted of six important sections: 1) learning objectives, 2) learning management, 3) evaluation, 4) expected learning outcomes, 5) media to be used in the classroom, and 6) post-lecture notes.

The lesson plans designed by the researcher integrated collaborative learning and case-based learning in the mathematics learning process to improve the analytical skills of Grade 6 students. The research instruments were reviewed for content validity by three mathematics experts.

In the second section of the mathematics lesson plans, the procedures for teaching and learning were as follows: 1) elicitation of prior knowledge, 2) case presentation, 3) case analysis through collaborative learning, and 4) conclusion and application.

3.2.2 *The Case Handbook for Mathematics.* The researcher created a case handbook for mathematics in which there were 30 real case studies or case studies based on true stories, which corresponded to the daily life of the learners and had contents related to mathematics. This case handbook for mathematics was reviewed for content and content validity by three mathematics experts.

3.2.3 *The Evaluation Form for Analytical Skills.* The evaluation form was designed to evaluate the analytical skills of Grade 6 students during each learning session. This evaluation was divided into the sub-skills of analytical thinking, based on Marzano's Taxonomy (2001). The sub-skills consisted of matching, classifying, analyzing errors, generalizing, and specifying. The researcher, as a teacher worked with a research assistant to observe and evaluate the analytical skills of each individual student in each group, with the use of an evaluation form for analytical skills. The rubrics used on the form consisted of a series of items to be scored using a five-point rating scale.

3.2.4 *The Mathematics Test*. The purpose of the mathematics test was to evaluate The mathematics knowledge of Grade 6 students before and after the class sessions. The questions on this test were divided into the sub-skills for analytical thinking, following Marzano's Taxonomy (2001), which are matching, classifying, analyzing errors, generalizing, and specifying. The test consisted of multiple-choice items with four choices for each item. The questions covered the eight content areas in the syllabus: five items regarding decimals; five items involving the addition, subtraction, and multiplication of decimals; five items involving the division of decimals; five items involving quadrilateral equations; five items involving circles; five items requiring application of knowledge; five items involving three-dimensional figures and the volume of cuboids; and five items involving basic statistics and probability. There were 40 items in all, worth a total 40 points.

3.2.5 *The Evaluation Form for Students' Attitude.* The evaluation form was designed to measure the attitude of Grade 6 students who were studying mathematics with a method integrating collaborative learning and case-based learning. This evaluation form for students' attitude consisted of two sections: Section 1 provided information about the informants, and Section 2 provided information about students' attitude toward the mathematics learning process integrating collaborative learning and case-based learning to improve the learners' analytical skills. The evaluation form consisted of a series of items to be ranked using a five-point rating scale. There were a total of 12 items which evaluated the skills of collaborative learning

and the skills of analytical thinking. This evaluation form was divided into five sub-skills: matching, classifying, analyzing errors, generalizing, and specifying; the overall attitude of students toward this learning process was also evaluated.

3.3 Behaviors Which Demonstrate the Skills of Analytical Thinking

The researcher specified the study of the analytical skills for this research in terms of behavior, according to Marzano's Taxonomy, as follows:

3.3.1 Matching. Students were able to determine the similarities and differences in what they have learned.

3.3.2 *Classifying.* Students were able to classify, arrange in order, and group objects with the same characteristics, based on similarity in the characteristics or in quality.

3.3.3 *Analyzing errors.* Students were able to sort errors or problems, notice the abnormality, see the relationships between objects and notice any incoherence among the objects, and link the relationships and develop a rational conclusion.

3.3.4 *Generalizing.* Students were able to use old knowledge to reach a conclusion involving new principles, apply their knowledge to new situations, and apply their knowledge for use in activities in their daily lives.

3.3.5 *Specifying.* Students were able to use their knowledge or existing principles to estimate or predict solutions in situations which could happen in the future, understand the situations, specify the details of the situations, and adapt and change methods to suit what might happen.

4. Data Collection

The researcher created five instruments to collect data: 1) mathematics lesson plans, 2) a case handbook for mathematics, 3) an evaluation form for analytical skills, 4) a mathematics test, and 5) an evaluation form for students' attitude.

The data were collected throughout one semester for the Grade 6 students in the academic year 2011. The semester consisted of fifteen weeks, with two class sessions per week. There were a total of 30 lecture sessions of 50 minutes per session. This research was conducted at Satit Bilingual School of Rangsit University.

5. Results

The results of this research can be divided into three parts as follows: (1) the researcher used the mathematics lesson plans and the case handbook for mathematics with the Grade 6 students; (2) the researcher provides the results for the development of analytical skills in mathematics in the target group; (3) and the researcher describes students' attitude toward learning mathematics using case studies with an emphasis on collaborative learning, as shown below.

5.1 The use of the mathematics lesson plans and the case handbook for mathematics with the Grade 6 students

5.1.1 Using case-based learning with an emphasis on collaborative learning to teach mathematics including the elicitation of prior knowledge, that is, introducing the lesson by stimulating the interest of students, informing them of the learning objectives and the method to be used for evaluation, and eliciting prior knowledge by presenting the background knowledge needed for the next step in the learning process.

5.1.2 The case presentation consisted of the following steps. First, the teacher presented the case studies as a medium for the management of teaching and learning. These cases for each session can be presented via one or more of the following forms: videos, films, printed materials, graphs, conversations, or stories. The selected case studies were derived from real stories or stories based on true stories. These case studies were related to the daily lives of the learners. Then the teacher described the problems involved and would add more information for students to use in their analysis.

5.1.3 In the analysis of the case studies, the learners analyzed the case studies through collaborative learning. The teacher divided students into small groups. Each group consisted of four or five members. Each group consisted of a student with a high grade, one or two students with average grades, and one or two students with low grades. This format was selected in order for the student with a high grade to assist the other students or to provide opportunities for students to exchange knowledge by highlighting the strengths of each individual student. At the same time, students were able to develop and to learn to overcome their weaknesses. Thus, collaborative learning, in this way, leads to positive interdependence.

At this stage, the teacher assigned each group of students to select a group leader, a Deputy chief, a secretary, and a quality controller who would check the accuracy of the assignments. Students listed their roles on the assignment sheets provided to them, so that the members of the group could be held responsible for their individual duties and so that the instructor could hold group members individually accountable. After that, the teacher assigned each group of students to work in teams on the problem sets, to analyze the problem sets, to find the answers and the conclusion, and to write the answers on the answer sheets provided. At this stage, students had to exhibit positive interdependence; have face-to-face pro-active interaction; brainstorm; and express their own opinions for other group members to acknowledge. In this way, students had to use interdependent and small group skills. That means that students had to know how to talk to their peers, how to work with their peers, and how to raise questions with the teacher when they had any doubts. Also, they had to work together and make maximum use of each member's abilities, so that the goal could be reached successfully. Success means that students got the right answers and their answers were relevant to the questions found in the case studies.

For the analysis using group processing, the teacher assigned each group of students to analyze their processes they had used after they had finished every case study. The teacher

assigned each group to evaluate the efficiency of their own group work. This was to see whether each member of the group had contributed to working towards reaching the goal successfully and how they could overcome their weaknesses. The results of this evaluation were used to inform the teaching and learning process in the next class.

5.1.4 Conclusion and Application. The conclusion and application process consisted of the following steps. 1) The teacher and students worked together in discussing and finding the answers to the problems, as well as summarizing the main points regarding what had been learned and expressed their opinions on how to apply their knowledge in their daily lives. 2) In addition, both the teacher and students collaborated in evaluating the results of their learning using various methods such as grading the assignments and observing students' behavior in their analytical thinking.

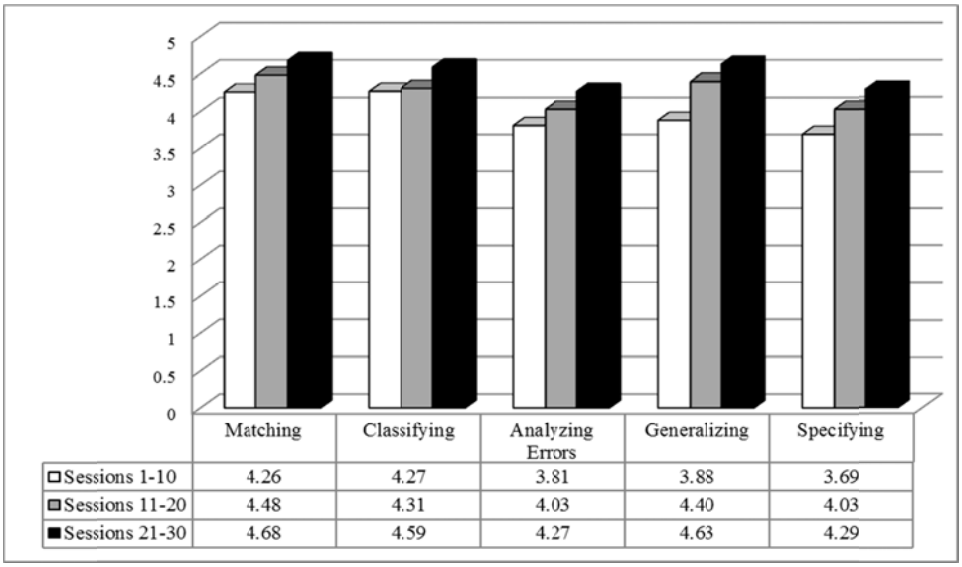
5.2 The Results of the Development of the Analytical Skills in Mathematics in the Target Group

5.2.1 The mean scores for the analytical skills of the target group of students, who learned mathematics via a method integrating collaborative learning and case-based learning were at a good level, as shown in Table 1.

Table 1: Mean Scores for the 5 Areas of Analytical Skills in the Target Group of Students (N=61)

5 Areas of Analytical Skills	**Scores**		
	Mean (μ)	**Standard Deviation (σ)**	**Level**
Matching	4.47	0.48	Good
Classifying	4.39	0.49	Good
Analyzing Errors	4.04	0.57	Good
Generalizing	4.30	0.72	Good
Specifying	4.00	0.70	Good
Total	**4.24**	**0.51**	Good

A comparison of the development in the five areas of analytical skills in the target group of students during Sessions 1-10, Sessions 11-20, and Sessions 21-30 reveals that analytical skills increased constantly, as shown in Figure 1.



	Matching	Classifying	Analyzing Errors	Generalizing	Specifying
Sessions 1-10	4.26	4.27	3.81	3.88	3.69
Sessions 11-20	4.48	4.31	4.03	4.40	4.03
Sessions 21-30	4.68	4.59	4.27	4.63	4.29

Figure 1: Development in the 5 Areas of Analytical Skills of the Target Group of Students

The mean scores for analytical skills in the target group of students who learned mathematics via a process integrating collaborative learning and case-based learning were at a good level, and the results improved steadily throughout the study. This was the conclusion of both the researcher and the research assistant. The increase in development was due to the fact that students exhibited positive interdependence, used the skills of working in groups, and practiced their analytical skills through the 30 case studies that varied in form and content. The constant practice of analytical skills, e.g. studying cases and reading comparative bar charts, gave students a better ability to think analytically.

For example, the researcher presented the students with a case study regarding the amount of carbon dioxide (CO_2) emissions by various countries, so that students could work in collaboration and analyze this case, as well as find the answers to the questions posed and practice their analytical skills in all five areas.

Sample Case Study Entitled "The Amount of Carbon Dioxide (CO_2) Emissions of Various Countries"

Many scientists fear that an increase in carbon dioxide (CO_2) emissions into our atmosphere will cause climate change. They have therefore calculated the amount of CO_2 emitted by various countries and regions, as shown in Figure 2 below. The figure shows the levels of CO_2 emissions in 1990 (white bars) and the emissions in 1998 (black bars) for the following countries: the USA, the USSR, Japan, Canada, Australia, the European Union, Germany, and the Netherlands.

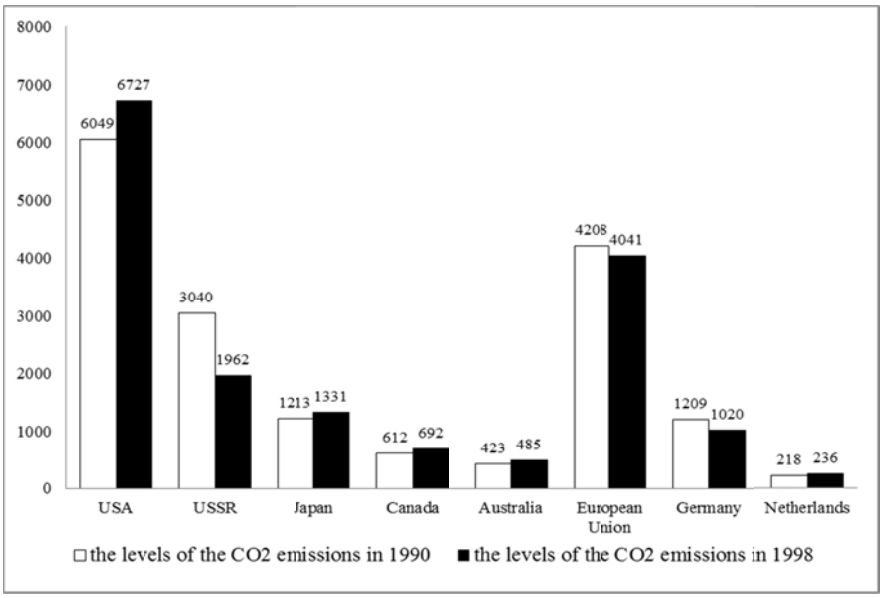


Figure 2: CO_2 emissions in 1990 (white bars) and 1998 (black bars)

Table 2: The Five Areas of Analytical Skill

The Five Areas of Analytical Skills	Questions
Matching	1. Compare the CO_2 emissions of the USA and Japan.
	2. Describe the differences between the USA and the USSR.
Classifying	1. Name the countries where the amount of CO_2 emissions has decreased.
	2. Name the countries where the amount of CO_2 emissions has increased.
	3. Arrange the countries in the order ranging from lowest emitter to highest emitter.
Analyzing Errors	1. Germany is an industrialized country. Why does it emit an amount of CO_2 at a relatively low level?
	2. In your opinion, which countries should take additional measures to control the amount of CO_2 emissions? Why?
Generalizing	1. In your opinion, can each country decrease the amount of CO_2 emissions? Why?
	2. How can you apply the knowledge you gained from reading the bar charts to use in your daily lives?
Specifying	1. Which countries have decreased the amount of CO_2 emissions? Why?
	2. From the data, do you predict that the CO_2 emissions will increase or decrease in 2013? Why?

From the case above, students practiced the sub-skills of analytical thinking through the process of case analysis using collaborative learning, conclusion, and application. After completing as many as 30 cases, students will have improved their analytical thinking.

5.2.2 The learning achievement of students before and after the mathematics learning process is classified into the five sub-skills for analytical thinking: matching, classifying, analyzing errors, generalizing, and specifying, as seen in Table 3 below.

Table 3: Mean Scores in Knowledge of Mathematics before and after the learning process for the Target Group of Students, Classified by the Sub-Skills of Analytical Thinking (N=61)

Sub Skills of Analytical Thinking (8 Points)	Point in Time Periods	Mean (μ)	Standard Deviation (σ)	Percentage (%)
Matching	Before the learning process	4.44	1.73	55.50
	After the learning process	7.66	0.57	95.75
Classifying	Before the learning process	3.44	1.74	43.00
	After the learning process	7.43	0.62	92.88
Analyzing Errors	Before the learning process	2.92	1.39	36.50
	After the learning process	7.41	0.69	92.63
Generalizing	Before the learning process	2.75	1.56	34.38
	After the learning process	6.90	0.96	86.25
Specifying	Before the learning process	3.26	1.42	40.38
	After the learning process	7.05	1.20	88.13

It can be seen from the mean scores for knowledge of mathematics before and after the learning process among the target group of students, divided into the sub-skills of analytical thinking, that mean scores after the learning process were higher than the ones prior to class sessions. In addition, the standard deviation decreased substantially for all sub-skills. When the target group of students studied mathematics via the learning process integrating collaborative learning and case-based learning, those students had competence higher degree of similarity in their competence in mathematics than prior to classes using this learning method. These results lead the researcher to have faith in the use of the pattern of activities that lead from the elicitation of prior knowledge through various activities such as asking questions and presenting examples. This stimulated the students' interest. Then students were informed of the learning objectives and their existing knowledge was elicited. This gave the students the goal of learning and sufficient knowledge to use in the next step. During the process of case analysis through the collaborative learning, students would learn together and exhibit positive interdependence. The talented students had chance to explain the information to the weaker students in order for them to understand. By using this process, the students who explained the information to their peers

could review their own knowledge and be proud that they could make their peers understand the lessons. As for the weaker students, they gained knowledge, understood the lessons, felt happy, and were ready to learn the next lesson.

It can be seen from the mean scores for knowledge of mathematics before and after lecture among the target group of students divided into the sub-skills of analytical thinking, that mean scores after lecture were higher than the ones prior to class sessions.

The stage of conclusion and application is very important as students collaboratively make conclusions about the knowledge they have gained and analyze the group learning process to make plans for the next class session. In addition, the case studies assigned to students to solve the problems together resulted in increased competence in mathematics among the students, e.g. in studying the topic of addition and subtraction of decimals. The researcher presented a case study about the great flood of 2011 with the following content. The great flood of 2011 caused great damage to the economy, and the property and possessions of many citizens. The news reported that this great flood in the central region of Thailand was caused by a large amount of water flowing down from the northern region of Thailand and joining the Chao Phya River to run into the Gulf of Thailand. However, the flood was enormous, and the drainage system was unable to drain off the flood waters in a timely manner. In addition, the big dams could no longer hold the water they stored, and thus a large amount of water was released from the dams, greatly increasing the amount of water. Furthermore, this water mass could not reach the sea quickly, and that caused a great flood over a large area. Many people say that if the dams had been able to hold the water and had not released water which increased the amount of the water, the great flood in the Central region of Thailand would not have occurred. In order to analyze this, the teacher asked students to go to the following website: <http://www.thaiwater.net/ DATA/REPORT/ php/ egat_ dam.php> to see the location of the dams and the amount of water held in them. Students were very interested in this case study, as it was something that had affected every student. When students went to the website, they saw the locations of the dams. Students chose the regions in which they were interested. They needed to find the total amount of water contained in all the dams. At this stage, students needed to help one another calculate the sum of the total amount of water in the dams. Then students used the results obtained for the sum to compare and contrast to see whether the amount of water in 2012 was greater or less than that in 2011. In this section, students were able to use their knowledge of subtraction of decimals.

When students learned about things around them and things that they had faced before, they got interested and paid complete attention.

5.3 Students' Attitude Toward Case-based learning in Mathematics with an Emphasis on Collaborative Learning.

The researcher calculated the mean scores for students' attitude toward case-based learning in mathematics with an emphasis on collaborative learning, which is equal to 4.86, at the highest level.

Table 4: The Mean Scores for the Evaluation of Attitude Among the Target Group of Students (N=61)

Items for Evaluation	Mean (μ)	Level of Attitude Standard Deviation (σ)	Level
Students gained knowledge and experience from participating in collaborative learning activities integrated with case-based learning.	4.77	0.46	highest
Students did activities which were appropriate for their level of knowledge in collaboration with their peers.	4.74	0.54	highest
Students analyzed case studies with up-to-date content based on stories relevant to their lives.	4.90	0.40	highest
Students worked in groups and exhibited positive interdependence.	5.00	0.00	highest
Students worked according to the roles and duties assigned by their group.	4.75	0.51	highest
Students raised questions and expressed their opinions.	4.59	0.62	highest
Students developed the skill of matching.	4.93	0.25	highest
Students developed the skill of classifying.	4.93	0.25	highest
Students developed the skill of analyzing errors.	5.00	0.00	highest
Students developed the skill of generalizing.	4.87	0.39	highest
Students developed the skill of specifying.	4.90	0.40	highest
Total Mean Score (μ)	**μ = 4.86**		**highest**

Table 4 shows that the total mean score for students' attitude toward case-based learning in mathematics with an emphasis on collaborative learning was 4.86, which is at the highest level. This can be explained that the high mean score for students' attitude is due to the fact that in the case studies questions were raised for students that forced students to practice and to learn to think analytically and systematically. The case studies also interested the students, who were active in the learning process. In their experience in collaborative learning, learners had the opportunity to participate in learning activities, exhibit positive interdependence and interact with others in their group work. This caused students to be happy with their learning, and this led toward overall success.

6. Discussion

Research results for the development of analytical skills in mathematics through the use of the case studies which emphasize collaborative learning are presented for the analytical skills in the target group of students in the following five areas: matching, classifying, analyzing errors, generalizing, and specifying, as described by Marzano (2001). The research results show that the steps in using lesson plans developed for mathematics and based on case studies and the use of group work in order to make learners collaborate with one another can be used with students who are studying mathematics at the primary level. The researcher recommends that class size should not exceed 30 students when using the case-based learning and collaborative learning methodology.

The researcher believes that teachers adopting this method should be well-rounded and have taught mathematics for a period of time in order to have the necessary experience. Teachers should understand the teaching method of placing learners at the center of instruction; should be interested in using learning management to encourage students to participate in learning activities; should plan activities that make teachers and learners interact with one another, so as to create meaningful learning experiences; and should be able to develop analytical skills. When teachers want to use this learning-management process in the classroom, they should truly understand the principles of case-based learning and should think about how to pass on effectively to the learners the content, knowledge, and experiences. This research, then, focused on learning management of collaborative learning (Johnson and Johnson, 1989; Susoarat, 2010). Thus, teachers who use this method have to understand the teaching principles and theories, as well as to be able to use learning management to cover all five factors: positive interdependence, face-to-face interaction, individual accountability, interpersonal and small-group skills, and analysis of the group processing. In terms of the support of developing students' analytical skills, teachers must prepare students to be ready by explaining the learning methods involved in the use of the collaborative learning process and case-based learning, the roles and duties of teachers and students, as well as the goals for learning management.

The researcher has outlined the procedures for using the case-based learning method and collaborative learning method in mathematics as follows: 1) teachers must be aware of students' learning background when dividing them into small groups; 2) teachers should put one student with good grades in each group, together with two or three students with average grades, and one student with low grades. This is to help students to help one another to learn. In addition, teachers must provide learning activities which stimulate students in each group to interact with one another to practice their analytical skills in the case studies (Muulkam, 2002; Khammani, 2010). Also, teachers should set roles and duties for students to enable them to complete their group work and reach the goals. In assessment and evaluation for this type of learning management process, teachers should use various and appropriate methods (Susoarat, 2010) by choosing a test for mathematics, an evaluation form for analytical skills, a form for group work, and a form for individual work, including feedback from teachers.

7. The Researcher's Suggestions

The researcher would like to suggest that the case-based learning and collaborative learning can be used in the teaching and learning of mathematics at both primary and secondary levels. In addition, teachers should master the use of systematic steps in learning management in terms of groups. Furthermore, members of the same group should have clearly designated roles and duties in order to reach the goals specified for learning in each session. Another point is that teachers should consider the fact that, in the end, the assessment in mathematics should be done individually. Thus, the use of group work should lead to individual problem solving in mathematics during the final session.

8. Acknowledgments

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9. The Author

Sumnuan Kunpol received her Ed.D. in Education from Rangsit University, M.Ed. in Curriculum and Instruction from Rangsit University, and M.Sc. (First Class Honors) in Computational Mathematics from Rangsit University. Currently, Sumnuan Kunpol is a teacher and Vice Chair of the mathematics content group, Satit Bilingual School of Rangsit University. Her research interests include the development of the analytical skills of students in mathematics and science.

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