Development of a Peer-to-Peer Mind Map Learning Activity for a Third-year Undergraduate Course in Quantitative Analysis for Decision Making in Business at Prince of Songkla University

การพัฒนากิจกรรมการเรียนรู้ด้วยผังมโนทัศน์ (Mind map) ร่วมกับเทคนิคเพื่อนช่วยเพื่อน วิชาการวิเคราะห์เชิงปริมาณเพื่อการตัดสินใจทางธุรกิจ สำหรับนักศึกษาชั้นปีที่ 3 หลักสูตร บริหารธุรกิจบัณฑิต มหาวิทยาลัยสงขลานครินทร์

Daranat Tansui

ดารานาถ แต่นสุ่ย

Faculty of Humanities and Social Sciences Prince of Songkla University, Pattani Campus

คณะมนุษยศาสตร์และสังคมศาสตร์ มหาวิทยาลัยสงขลานครินทร์ วิทยาเขตปัตตานี

daranat.t@psu.ac.th

Abstract

This research study was a development of a mind-mapping learning activity, supplemented with a peer-to-peer technique. The developed activity was for a course called quantitative analysis for effective business decision, while the development goal was to achieve a ratio (E1/E2) of 80/80 for the developed activity. In addition, the study included determining the learning activity's effectiveness index and surveying the students' attitude towards the arrangement of teaching and learning of this course. The sample group was 18 3rd-year   students at Songklanagarinda University, Pattani Campus, purposedly selected from a population of 32. The determination of learning achievement was based on a one-group, pre-test, post-test experimental design, statistically analyzed with a paired-sample T Test. The results of this study were found as follows: The outcomes of the first objective were the following: E1 was 81.63, higher than the standard criterion of 80; E2 was 82.24, also higher than the standard criterion; the average student post-test score of 30.21 (S.D.=4.70) was significantly higher than the pre-test score of 23.93 (S.D.=6.25). The outcome of the second objective was a good efficacy index of 0.63. Finally, the outcome of the third objective was that the students had an excellent-level attitude toward the course.

Keywords: mind map, peer-to-peer, effectiveness index E_1/E_2

บทคัดย่อ

การวิจัยครั้งนี้เพื่อพัฒนากิจกรรมการเรียนรู้ผังมโนทัศน์ร่วมกับเทคนิคเพื่อนช่วยเพื่อนวิชาการวิเคราะห์เชิง
ปริมาณเพื่อการตัดสินใจทางธุรกิจที่มีประสิทธิภาพ (E1/E2) ตามเกณฑ์ 80/80 เพื่อเปรียบเทียบผลสัมฤทธิ์ทางการเรียน
รวมถึงศึกษาดัชนีประสิทธิผลของกิจกรรมการเรียนรู้ และศึกษาเจตคติของนักศึกษาที่มีต่อการจัดการเรียนการสอนวิชา
วิเคราะห์เชิงปริมาณ ทำการทดลองกับนักศึกษาชั้นปีที่ 3 มหาวิทยาลัยสงขลานครินทร์ วิทยาเขตปัตตานี มีประชากร 32
คน เลือกกลุ่มตัวอย่างแบบเฉพาะเจาะจง ได้ 18 คน ใช้แผนการทดลองแบบ one group pre-test post–test design
โดยการวัดผลสัมฤทธิ์ทางการเรียนก่อนและหลังการจัดกิจกรรมการเรียนรู้ โดยวิเคราะห์ข้อมูลวิเคราะห์ด้วยวิธี Paired –
Samples T Test ผลการวิจัยมี ดังนี้

ผลการวิจัยพบว่า ประสิทธิภาพการจัดการเรียนรู้ด้วยผังมโนทัศน์ร่วมกับเทคนิคเพื่อนช่วยเพื่อนมีประสิทธิภาพ
ของกระบวนการเรียน (E1) เท่ากับ 81.63 ซึ่งสูงกว่าเกณฑ์มาตรฐาน 80 ตัวแรก ประสิทธิภาพของผลลัพธ์ (E2) เท่ากับ
82.24 นักศึกษามีผลสัมฤทธิ์ทางการเรียนหลังเรียนสูงกว่าก่อนเรียนอย่างมีนัยสำคัญทางสถิติที่ .01 โดยมีคะแนนเฉลี่ยก่อน
เรียนเท่ากับ 23.93 (S.D.=6.25) และหลังเรียนเท่ากับ 30.21 (S.D.=4.70) มีค่าดัชนีประสิทธิผลของการจัดการเรียนรู้
เท่ากับ 0.63 สุดท้ายพบว่า นักศึกษามีเจตคติต่อการจัดการเรียนการสอนด้วยกิจกรรมการเรียนรู้ผังมโนทัศน์เสริมด้วย
เทคนิคเพื่อนช่วยเพื่อนในภาพรวมเห็นด้วยจัดอยู่ระดับดีมาก

คำสำคัญ: ผังมโนทัศน์เสริม เทคนิคเพื่อนช่วยเพื่อน ประสิทธิภาพตามเกณฑ์ E1/E2

Introduction

Quantitative analysis in management science is an analysis method based on the universal
scientific method, the outcome of which can be used in management-decision making. Since quantitative
analysis is based on the scientific method, it inherits the power of prediction, rigor, and validity of the
successful scientific method. It is a basic knowledge required for conducting research studies (Wuthisatian
& Thanetsunthorn 2019). Having to cope with learning activities that mostly consisted of series of lectures
and lots of exercises, the students became bored with the course. Hence, the course has had to be
redesigned: shifting the focus on memorization of basic information to a focus on understanding the
basic principles and processes of quantitative analysis, enabling students to apply them successfully to
new problems. Students should be able to gain more understanding from a variety of activities focusing
on applications of the principles and processes (Parndarong 2017).

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analysis is based on the scientific method, it inherits the power of prediction, rigor, and validity of the
successful scientific method. It is a basic knowledge required for conducting research studies (Wuthisatian
& Thanetsunthorn 2019) A properly designed mind-mapping technique enables a systematic organization
of information and thought processes that fulfills the operational requirements of both the right and the
left brain. From the author's personal experiences in investigating theories and principles in the literature
related to the mentioned problem as well as in analyzing the problem encountered in real-life

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quantitative analysis classes, the author had discovered that a variety of teaching methods could potentially solve this problem. However, there was no perfect method; each one had different strengths and weaknesses.

Therefore, the author attempted to develop a mind-map learning activity that is carried out with peer-to-peer technique to be conducted in a quantitative analysis course. Peer-to-peer technique has been demonstrated to give learners opportunities to demonstrate their knowledge and skills, to help other people, and to develop a sense of responsibility, which in turn, made learners become more interested in the subject and made them understood it better (Kaewmani 2018) Peer-to-peer technique and activities provide opportunities for learners to help some of their peers to learn topics that the learners have already accomplished a good understanding. In peer-to-peer activities, learners practice interacting with their peers, listening to the opinion of each peer in the group, and commenting to exchange their understanding. These technique and activities promote good relationship building among learners and better learning outcomes. Apart from these advantages/strengths, they enable the instructor to know the learners, their differences, and their learning progress better so that the instructor can plan better teaching and learning activities for them (Srisampan, Sirisakulpaisan & Foneboreman 2018).

The author hoped that this peer-to-peer, mind-map activity would help improve the learning outcomes of quantitative analysis course for future 3 rd year students in business administration at Prince of Songkla University. If proven successful, this peer-to-peer, mind-map learning activity could be a teaching and learning innovation for other difficult mathematical and related subjects. Their expected potential would be clearly confirmed as they were further developed and applied in other real-life classes.

Research Objectives

1. To develop a mind-map with peer-to-peer teaching and learning activity for a course entitled "quantitative analysis for making business decision" for 3rd-year students majoring in business administration at Prince of Songkla University, Pattani Campus, such that the activity would meet the 80/80 (E1/E2) standard.

2. To compare the pre-test and post-test outcomes of 3rd-year students taking the "quantitative analysis for making business decision" course with peer-to-peer mind-map activity at Prince of Songkla University, Pattani Campus.

3. To determine the effectiveness index of the peer-to-peer mind-map activity in this course.

4. To survey the attitudes of 3rd-year students majoring in business administration at Songklanakarin University, Pattani Campus, towards the "quantitative analysis for making business decision" course.

Definitions

1. Peer-to-peer mind-map teaching and learning technique is a technique that assigns learners a tutoring role in class. Learners assist their classmates in a small group, and the group gains a better

understanding of the topic of interest. In this study, the author brought a mind-map concluding technique into the class. The students connected parts of information together, analyzed, and synthesized a conclusion.

2. Mind map is a diagram or an illustration of relationships between the main or important ideas, with branches of lower-level ideas spread out in all directions. The main idea is drawn at the middle of the diagram, and the lower-level ideas branch out from it in all directions, much like the branching of neuron cells of human beings. Each idea is connected to other ideas with a line, and it can be connected to many other ideas, surrounding it.

3. Single type means that a strong student, a medium student, and a weak student were grouped into a peer-to-peer learning unit.

4. Group type means that a group of three strong students, a group of three medium students, and a group of three weak students were grouped into a peer-to-peer learning unit.

5. Field type means that 25 students were grouped into a peer-to-peer learning unit. Those 25 students in each unit were a non-controlled variety of mixed strong, medium, and weak students.

Theories and Related Literature

1. Mind mapping

1.1. Meaning of mind mapping

Mind map is a tool for examining whether students have understood a course content correctly. It is a pictorial diagram of connections between ideas of the content being learned, main and lower-level ideas, which help students understand the content better and promote meaningful learning (Kaewmani 2018). Another previous study (Srisampan, Sirisakulpaisan & Foneboreman 2018) stated that a mind map shows the connections between ideas of a course content clearly, enabling students to make valid conclusion of the content in their own words, not just memorizing the theory or definition with no real understanding. This kind of understanding will lead to a better learning outcome. Their statement is fully supported by another study (Wongpattanakijmanop 2019) showing that mind-mapping activities and a learning-assistance computer program called 'Plickers' helped improve the learning outcomes of 1st-year cadets and were perceived positively by them.

1.2 Teaching and learning format with mind-mapping

Mind map was developed based on established cognitive theories. It is a tool for helping students to connect pieces of information and ideas about a particular subject that will lead to a better understanding of the subject, which will enable valid analysis of the content, good judgement of its reasonableness, and creative extension or application of the content Mind map can be classified into four types: 1) spider concept map: this kind of map places the main idea of the subject at the middle of the diagram and the lower-level ideas around it, surrounding it, as shown in Figure 1; 2) hierarchy concept map: this kind of map places the main idea at the top of the diagram and the lower-level ideas below it, as shown in Fig. 2; 3) flowchart concept map: this kind of map places each idea according to

its linear sequence in a considered procedure; and 4) system concept map: this kind of map arranges ideas as inputs and outputs of a procedure, as shown in Fig.1-4.
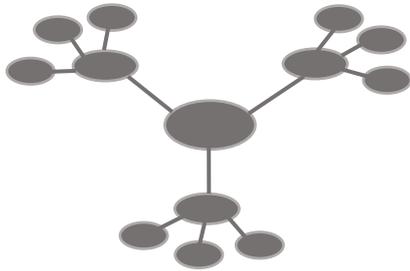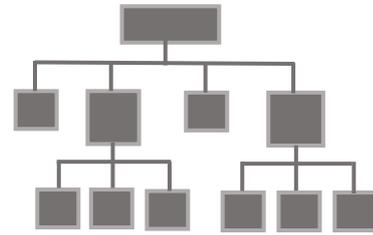
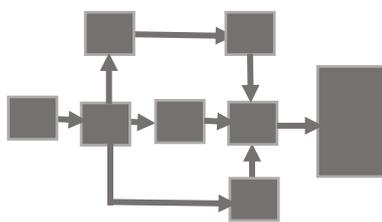Fig. 1 Spider Concept Map

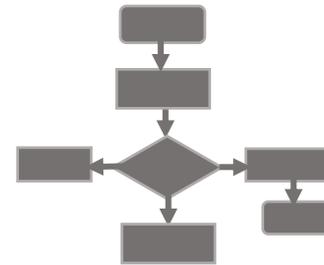Fig. 2 Hierarchy Concept Map

Fig.3 Flowchart Concept Map

Fig. 4 System Concept Map

Fig.1-4. Hierarchy Concept Maps (Buhmann & Kingsbury 2015)

2. Peer-to-peer learning

2.1 Meaning and significance of peer-to-peer learning

Peer-to-peer learning or peer tutoring is a teaching and learning method that some or all individuals in a group of students take turn playing a tutor role for one or more of the other students, supporting and encouraging each other. In preparing to tutor other students, the student will have to try to understand the content clearly and fully, so his or her understanding of the content will be developed to the full potential. The role of the teacher is to provide peer-to-peer learning activities that will truly boost the students' potential. Peer-to-peer learning can be classified into the following types: Cross-Age Tutoring,Reverse-Role Tutoring, and Classwide-Peer Tutoring (Bootdeewong, Aneksook & Ngammeerit 2019). Peer-to-peer learning or peer tutoring benefits the academic achievement of both the tutor and the tutees. The primary objective of this learning method is to improve the academic achievement of weak students and students with learning or behavioral problems. It is believed that peer-to-peer learning can help slow students to catch up with the class.

2.2 Principles of peer-to-peer learning

Peer-to-peer learning principles are based on social dependency theory was a social action is driven by a group of individuals with diverse opinions but a common goal. Any change to the state of an individual or a subgroup will affect a consequent change to the states of all other individuals or subgroups of the group. The collective power of every individual in the group drives the group to accomplish its intended goal. A study that supports the effectiveness of peer-to-peer learning is a study

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by Tanma (Tanma 2018). In that study, she evaluated the learning outcomes on the topic of fraction of primary school students (4th-6th grade) with lessons constructed with a peer-to-peer technique and mixed media and found the effectiveness to be 88.96/84.92, much higher than the expected 80/80, with an E.I. of 0.74. The pre-test and post-test learning outcomes were significantly different at $p < 0.05$. Moreover, the students were highly satisfied with the teaching and learning (the highest level defined in the study).

Conceptual framework

The conceptual framework of this study is explained in the three boxes below.

Input	Methodology	Output
1.Eighteen purposedly selected students into three groups, each with six strong, medium, and weak students 2. Mind-mapping and peer-to-peer teaching and learning activities. 3. trial duration of 90 days.	1. Construct such activities based on related theories. 2. Conduct a pre-test, then the activities, then a post-test. 3. Analyze the test results with Paired – Sample T Test.	1. A higher students' academic achievement. 2. Students had a good attitude towards the subject course.

Methodology

1. The population and sample group of this study were 3rd-year students majoring in business administration and taking a quantitative analysis for making business decision course, at Prince of Songkla University, Pattani Campus. The whole population was 32 students. Individuals in the sample group were purposefully selected based on the outcomes of a test on mathematical knowledge. The final sample group consisted of 18 students, classified as 3 groups of 6 students whose test outcomes were good, average, and poor.

2. Research tools

2.1. Measuring tools are tools that the author used to collect data for determining the dependent variable: a test of learning outcome, an evaluation form for peer-to-peer mind-map teaching and learning, and an attitude evaluation form.

2.2. Peer-to-peer mind-map lessons and lesson plans for the quantitative analysis for making business decision course.

3. Construction and validation of research tools

3.1 The lessons were initially developed from an investigation of the issue and the obstacles of inadequate learning outcomes in the quantitative analysis for making business decision course in Bachelor's degree programs. Then, after the analysis of the issue and obstacles, lessons were constructed. The content was partitioned according to class time. The behavioral objectives were defined. Next, the mixed-media lessons were examined by experts. The structural consistency of the lessons and the validity of the content were verified by experts, responding to a quality evaluation form. Their responses were one of five levels of a Likert scale. The acceptable level of quality was set at 3.51, and the experts' responses were 3.87, verifying that the developed lessons were of acceptably high quality.

The outcomes of the effectiveness evaluation of the mixed-media lessons of 1:1 type) single type were E_1=66.33 and E_2=65.67 The weak points in the lessons were addressed. Then, the effectiveness evaluation of the mixed-media lessons of 1 10:type (group type (was performed. The outcomes were E_1 =77.89 and E_2 75.89 =. Next was an effectiveness evaluation of the mixed-media lessons of 1 : 100 type) field type .(The outcomes were E_1=80.32 and E_2 .80.56 = Therefore, it could be concluded that the developed peer-to-peer mind-map mixed-media lessons for quantitative analysis for making business decision course were of a higher quality than the specified 80/80 standard, and they were proper for the sample group to learn from.

The mathematical formulas for calculating the effective index (E.I.) are reported in a previous paper (Promwong 2013).

(1) Formula for calculating learning effectiveness (the first 80%)

$$E_1 = \frac{F_1 \times 100}{A_1},$$

Where E_1 is the percentage level of pre-learning effectiveness;

F_1 is the average score achieved during learning every lesson;

A_1 is the total test score of every lesson.

(2) Formula for calculating learning effectiveness (the final 80%)

$$E_2 = \frac{F_2 \times 100}{A_2},$$

Where E_2 is the percentage level of post-learning effectiveness;

F_2 is the average score achieved after learning every lesson;

A_2 is the total test score after learning every lesson.

(3) Calculation of effectiveness index (E.I.)

$$E.I = \frac{P_2 - P_1}{(number\ of\ student \times Total\ score)}$$

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Where P_1 is the sum of all post-test scores for every lesson; and

P_2 is the sum of all pre-test scores for every lesson.

3.2 The lesson plans were initially developed by a review of papers related to mind-mapping and peer-to-peer teaching and learning technique. Next, the content of the course was analyzed, and the expected learning outcome was defined. The design of the lesson plans was based on the expected learning outcome. The developed lesson plans were examined by experts. They made suggestions on improvements and verified that the developed plans were suitable for the study. The suggestions were implemented, and the final lesson plans were ready for in-class uses.

3.3 The test of learning outcome was developed by the author, and then examined by experts, in terms of content validity. The experts selected only the developed test items that achieved an IOC (Index of item objective Congruence) of 0.50 or higher. The selected items were then tested with a group of students to find any weak points. Those weak points having been addressed, the final test of learning outcome was ready for use later in the study.

3.4 The attitude survey form was constructed according to a theory of evaluation [ref] and examined by five experts. They selected only the developed survey items that achieved an IOC (Index of item objective Congruence) of 0.70 or higher. Evaluated by Cronbach alpha coefficient method, the final survey form achieved a reliability index of 0.80. It was further used in the study.

4. The author collected the data according to a one-group pre-test post–test design as follows (Table 1).

Table1 One-group pre-test post–test design

Pre-test	During teaching	Post-test
T_1	X	T_2

Symbols:

T1 represents measured learning outcome before the peer-to-peer mind-map activities was conducted (pre-test).

X represents measured learning outcome while the peer-to-peer mind-map activities was conducted.

T2 represents measured learning outcome after the peer-to-peer mind-map activities was conducted (post-test). Note: T1 and T2 were measured with the same test.

5. The basic statistics used for analyzing the data were, S.D., and percentage, while those used for testing the hypotheses were E1/E2, t-test, and Goodman, Fletcher, and Schneider method. and the paired-sample T Test was conducted at $p < 0.01$. The formulated hypotheses of this the following:

H0 : The average post-test score on a quantitative analysis subject course of the students learning with a mind-mapping technique and a peer-to-peer technique studying is no different from the average pre-test score.

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H1 : The average post-test score on a quantitative analysis subject course of the students learning with a mind-mapping technique and a peer-to-peer technique studying is higher than the average pre-test score.

Results

1. The results on the effectiveness of the peer-to-peer mind-map teaching and learning activities are as described in the following sub-sections.

1.1 Overall, E1 = 81.63, higher than the specified standard of 80. the effectiveness of the peer-to-peer mind-map teaching and learning activities (Table 2).

1.2 Overall, E2 = 82.24, higher than the specified standard of 80 (Table 2) Since E1/E2 was 81.63/82.24, higher than the specified standard of 80/80, it could be concluded that the peer-to-peer mind-map teaching and learning activities developed for the quantitative analysis for making business decision course for 3rd-year students majoring in business administration at Prince of Songkla University, Pattani Campus, were effective (Table 2).

Table 2 Effectiveness of peer-to-peer mind-map teaching and learning activities

Score	Total score	Mean	Percentage	E_1 / E_2
During the course	125	101.39	81.63	81.63/82.24
Post-test	125	102.50	82.24	

2. The average pre-test score was 23.93 (S.D.=6.25), and the average post-test score was 30.21 (S.D.=4.70). The result of hypothesis testing with t-test indicated that the average post-test score was significantly higher than the average pre-test score at $\alpha < .01$ (Table 3).

Table 3: Learning outcomes of students with peer-to-peer mind-map teaching and learning activities

Item	Pre-test (N=18)		Post-test (N=18)		t	Sig
	$\overline{X}$	S.D.	$\overline{X}$	S.D.		
1) Inventory	4.91	1.40	6.07	0.83	-3.77	.002 **
2) Simulation	5.13	1.32	6.02	1.08	-3.82	.001 **
3) Markov chain	4.76	1.49	5.97	1.13	-4.64	.000 **
4) Linear programming	4.59	1.43	6.18	1.04	-4.61	.000 **
5) Making decision	4.52	1.51	5.95	1.13	-4.10	.001 **
Total	23.93	6.25	30.21	4.70	-5.48	.000 **

** p<.01

3) The E.I. Effectiveness Index of the peer-to-peer mind-map teaching and learning activities was 0.63, indicating that the participating 3rd-year students majoring in business administration at Prince of

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Songkla University, Pattani Campus, successfully assimilated new knowledge at 63.00% of the average score in Table 4.

Table 4 Effectiveness index (EI) of peer-to-peer mind-map teaching and learning activities

No. of students	Total score	Score		Percentage		E.I.
		Pre-test	Post-test	Pre-test	Post-test	
18	35	399.90	543.80	63.47	86.32	0.63

4. Overall, the surveyed students' attitudes towards the peer-to-peer mind-map teaching and learning activities was very good, with an average score of 4.43 (S.D.=0.35). Classified according to individual aspect of the activities, the highest attitude score was on the instructor aspect, at 4.63 (S.D.=0.39), followed by the teaching aspect, at 4.41 (S.D.=0.45) and the subject aspect, at 4.27 (S.D.=0.46) (Table 5)

Table 5 Level of surveyed attitudes towards peer-to-peer mind-map teaching and learning

Aspect	$\overline{\text{X}}$	S.D.	Interpretation
1) Instructor	4.63	0.39	Excellent
2) Teaching	4.41	0.45	Very good
3) Testing and evaluation	4.41	0.44	Very good
4) Subject	4.27	0.46	Very good
Total	4.43	0.35	Very good

Discussion

The effectiveness of peer-to-peer mind-map teaching and learning activities for quantitative analysis for making business decision course for 3rd-year students majoring in business administration at Prince of Songkla University, Pattani Campus, Thailand, was 81.63/82.24, higher than the specified standard of 80/80. Furthermore, the average post-test score was significantly higher than the average pre-test score at $\alpha < 0.01$. The E.I. was 0.63, and the level of students' attitude towards the activities was very good (=4.43). The values of all these indicators exceed the target values that we set as our criteria for acceptance of our hypotheses, implying that these activities can be used to improve students' academic achievement for related courses and similar groups of students.

Of note is that in recent literature, there have been many studies reporting that peer-to-peer mind-map teaching and learning activities not only supported memorization of the content of the course, but also promoted deeper understanding. For example, a study by Komolmak (Komolmak 2017) concluded from the mind maps that the students produced that the students have accrued new knowledge more readily. the strengths and weaknesses of each student were also observable through

the mind-maps that he or she produced. Any errors that they made can be traced back to the improper connections between ideas in the mind map, hence the instructor or tutor could remedy the errors exactly at the roots of the misunderstanding. For all of these reasons, it can be concluded that the peer-to-peer mind-map teaching and learning activities were effective activities for teaching and learning the quantitative analysis for making business decision course, and they can be adapted for uses in other related courses.

This conclusion agrees well with findings from other studies that investigated mind-map technique in a variety of courses and levels. For instance (Tanma 2018) investigated the learning outcomes of a course on fraction conducted with peer-to-peer technique for 4th-year primary school students and found that the achieved E1/E2 was 88.96/84.92, higher than the specified 80/80 standard. The E.I. was 0.74, and the level of student's satisfaction with the course was excellent. For another instance, Komolmak (Komolmak 2017) investigated the learning outcomes of a financial management course with peer-to-peer activities for 2nd-year high school students at Samsen Wittayalai School, Thailand, and found that the average pre-test score, at 58.40%, was much lower than the average post-test score, at 89.05. Similarly, Parndarong (Parndarong 2017) investigated the learning outcomes of an English for professional communication course with peer-to-peer activities at Lampang Technical College, Thailand, and found not only that the average post-test score was higher than the average pre-test score, but also that the students were highly satisfied with the peer-to-peer activities.

Suggestions

1. Suggestions on how to use the findings from this study

1.1 The instructor should use this peer-to-peer technique in several related courses.

1.2 The instructor should take students' readiness into consideration. For example, the students should primarily be well-versed on the basic vocabulary of the topic of interest.

2. Suggestions for future research

2.1 Peer-to-peer mind-map technique should be applied to an integrated group of related courses.

2.2 PARS, Principals Assessment Review Schedule, should be applied to investigations of learning outcomes.

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