Science and Mathematics Education Centre

Effectiveness of the Use of Activity, Classroom Discussion, and Exercise (ACE) Teaching Cycle in Elementary Linear Algebra Course at Padang State University

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This thesis is presented for the Degree of Doctor of Philosophy of Curtin University

April 2013
DECLARATION

This thesis contains no material which has been accepted for any award of any other degree or diploma in any university. To the best of my knowledge and belief, this thesis contains no material previously published by any other person except where due acknowledgement has been made.

Signature:

Hendra Syarifuddin

Date: 12/07/2013
ABSTRACT

The major objective of this study was to develop, implement, and evaluate the use of the Activity, Classroom discussion, and Exercise (ACE) teaching cycle approach in an Elementary Linear Algebra course. The main focus of the study was to identify the effects of the ACE teaching cycle approach on students’ engagement and learning. The Elementary Linear Algebra course was delivered at the Mathematics Education Study Program of Padang State University, Indonesia.

An action research methodology was adopted for the study and the constructivist theory was used as a theoretical framework. This study used mixed methods to collect, describe, and interpret the data. The data were collected through focus group discussion, classroom observations, questionnaire, concept maps, students’ reflective journals, and the lecturer’s research journal. The participants in this study consisted of 37 students enrolled in the Elementary Linear Algebra course during the January-June 2011 semester. The ACE teaching cycle approach that was implemented in this study consisted of three steps. The first step in this cycle was the concept maps activity. This activity encouraged students to prepare for the topics that would be discussed in the class. The next step was classroom discussion which provided a social context in which the students could work together to solve mathematics problems. Finally, exercises were assigned as homework. In this part, students practised solving mathematics problems and wrote reflective journal.

Students’ involvement in the ACE teaching cycle approach in the Elementary Linear Algebra course improved their engagement in mathematics learning in the three domains of cognitive engagement, affective engagement and behavioural engagement. The approach has given students the opportunity to develop their understanding on concepts and procedures, problem solving ability, and communication ability.
DEDICATION

This thesis is dedicated to the memory of my father, Thaib Datuk Sutan Mangkuto. May Almighty Allah (God) have mercy on him and rest his soul in heaven.

This thesis is also dedicated to my family, including my beloved mother (Rosna), my wife (Wiwik Rahayu), my sister (Nurbaiti), my brothers (Mulyadi and Rusdi), and my wonderful children (Salsabila, Hasfi, Rafif, and Olivia).
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1.1 Introduction

The purpose of this research was to improve teaching and learning mathematics in higher education in Indonesia. Two issues that have been encountered in education in Indonesia are the low level of students’ engagement and their learning in mathematics. As a mathematics lecturer at Padang State University, I also found that these two issues have become major problems of my teaching practice. Students’ engagement in the teaching and learning process is a significant goal in education (Elmore, 1990). Despite its importance, student disengagement in learning is still a problem in education. Disengagement leads to reducing the variety of knowledge and information that can be achieved by students in their learning. In addition, students who are disengaged in learning limit their capacity to understand their learning experiences (Attard, 2011). This similar state of affairs concerning students’ learning in mathematics is a problem in mathematics education. Many students perform poorly in mathematics because they are unable to adequately handle information that is related to the concepts and procedures necessary for them to communicate mathematics ideas and to be involved in mathematics problem solving (Maharaj, 2011).

To improve my teaching and learning practice and to overcome these two issues I chose to implement the Activities, Classroom-discussion and Exercises (ACE) teaching cycle approach (Arnawa, 2006; Asiala, Cottrill, Dubinsky, & Schwingendorf, 1997; Dubinsky, 1995). The ACE teaching cycle is an instructional model that is based on constructivist theory. This study investigated the impact of the use of the ACE approach on students’ engagement and students’ learning in mathematics. The ACE teaching cycle is expected to improve students’ learning and to improve students’ engagement.
This study was conducted in the Mathematics Education Study Program of the Padang State University in Semester 2 (January – June) of the academic year 2010/2011. Padang State University is a public university which was established in 1954. It ranks as one of the two biggest universities in West Sumatera province, Indonesia. It provides undergraduate courses across seven faculties. Padang State University is one of the higher education institutions in Indonesia that prepares teachers for schools. The primary mission of the Mathematics Education Study Program of Padang State University is to provide the preparation of mathematics teachers who will teach mathematics at junior high school or senior high school. After students complete their undergraduate degree they are expected to (1) be able to think logically and analytically when solving mathematics problems, (2) possess the necessary knowledge in mathematics, (3) possess knowledge teaching and learning mathematics, (4) have ability in communication, (5) display good behaviour and (6) have the ability to adapt in their work place and in society (Penyusun, 2005).

This chapter is an introduction to the thesis and is presented in seven main sections. Section 1.2 discusses the background and rationale of the study. The research purposes are presented in section 1.3. Section 1.4 introduces the specific research questions which guide the study followed by the significance of the study that is presented in section 1.5. Section 1.6 presents the thesis structure and finally a summary of the chapter is presented in section 1.7.

1.2 Background and Rationale of the Study

The teacher training college is the place where pre-service teachers can get knowledge and skills that prepare them to enter the working world. The knowledge and skills that are acquired by students must be appropriate for the needs of their career in teaching. The knowledge and skills that are acquired by prospective mathematics teachers are not only the content knowledge and skills about mathematics but also the pedagogical content knowledge necessary for them to be capable mathematics teachers (Livy & Vale, 2011). According to
Schulman (1998) pedagogical content knowledge is the knowledge that relates to the ways the teacher represents and formulates their knowledge when teaching. Mathematical content knowledge and pedagogical content knowledge are two important dimensions that proficient mathematics teachers require (Livy & Vale, 2011; Ma, 1999). The specific subject in which this research was carried out targets the development of mathematics content knowledge of prospective teachers.

According to Taplin (1998) it is often difficult to equip students with the necessary mathematical knowledge because most students enter college with inadequate mathematics skills. As a result, these students experience difficulty in understanding the mathematics concepts because most concepts in mathematics relate to abstract ideas that are related to each other. Students will face difficulties in studying mathematics if they have lost the link between concepts. According Brijlall and Maharaj (2009), many students perform poorly in mathematics because they are unable to adequately handle information given in symbolic form which represent objects, for example mathematical expressions, equations and functions. Besides that problem, according to Maharaj (2011) a high percentage of students have a static view about mathematics; students with such a view will experience difficulties in learning mathematics in depth and will find it difficult to engage in teaching and learning processes. So, these problems are related to students’ mathematics learning and students’ engagement in the classroom.

Another problem of teaching mathematics to prospective mathematics teachers is the teaching and learning process in some teachers’ colleges still involves the teacher-centred approach. This teacher-centred teaching and learning approach does not give the optimal provision for students to be able to be proficient teachers. In the teacher-centred classroom, students’ display high dependence on the lecturer to acquire knowledge and skills while their opportunity to interact and socialize between them is very limited. The prospective teachers need the opportunity to develop as independent learners. This ability will help them to grow successfully in their careers as teachers. In college, students must also
develop their abilities in socializing, discussing, and sharing of ideas between themselves (Dikici, 2006; Pedro & Brunheira, 2001).

Padang State University is the largest university in West Sumatra, Indonesia that prepares teachers for primary and secondary schools. Based on my experience as a staff member of Padang State University, I can say that most of the teaching and learning processes at the university are still conducted traditionally where lecturers become the main actors in the classroom – also known as teacher-centred teacher. The teaching and learning process follows the same pattern for each session. Generally, mathematics lectures follow four teaching steps when they teach mathematics: 1) explaining the topic, 2) giving examples, 3) asking students to do exercises, and 4) giving homework. According to Nesmith (2008) the lecturer’s role in traditional mathematics classroom is to (1) provide all topics which are planned, demonstrate procedures, (2) reiterate steps in answering students’ questions, (3) provide sufficient opportunities for students to be drilled in the procedures, and (4) offer specific corrective support. These roles identify the lecturer as a central figure in the teaching and learning process and portray students as receivers of knowledge in the classroom. The traditional curriculum is based on the transmission of knowledge from lecturer to students and does not encourage students to be actively involved in the classroom (Kent, Gilbertson, & Hunt, 1997). As a result, students are unable to acquire a variety of experiences in the learning process and their learning outcomes might be restricted to knowledge of content and related skills.

The main features of the traditional curriculum are lecturer domination over organisation and action, teacher selection and transfer of knowledge (Exley, 2008). Regarding organisation and action, the lecturer is the central figure who organises the contents of the course and the strategies that will be implemented in the classroom. The next feature of lecturer selection requires the lecturer as the person who decides what topics are to be presented and what strategy will be used to present the topics. As for transfer of knowledge, the lecturer tends to explain her or his knowledge in the classroom. S/he is more concerned with the
completeness of giving materials and focuses on how far students understand the contents of the course. In such a curriculum, most of the time in the classroom is allocated to support direct transfer of knowledge from the lecturer to students. Lecturer domination in the classroom does not result in the maximum benefit of students’ engagement and learning in the classroom.

In the teaching and learning process using the traditional curriculum, students are passive while the lecturer dominates class activities. Students are not provided with sufficient opportunities to learn through various sources and various activities, thus limiting their engagement and their learning. In term of students’ engagement, students do not have sufficient opportunities to be involved in the teaching and learning process. Students lack opportunities to deepen their understanding, and are provided with limited opportunities to develop their self-learning ability and to communicate with each other in the class. Classrooms that are dominated by the lecturer also have a negative impact on students’ affective engagement like interest and achievement orientation, and behavioural engagement like attentiveness and diligence (Kong, Wong, & Lam, 2003). In terms of students’ learning, students do not have sufficient opportunities to improve their understanding of concepts and procedures as well as to improve their ability in problem solving and communication (NCTM, 2000).

Teaching and learning mathematics should enable students to acquire a variety of experiences through various sources and activities so that students have more opportunities to increase their engagement in the teaching and learning process. Evidence shows that the focus of the teaching and learning process must be the students as in student-centred learning instruction. Hence, the lecturer must function as a facilitator and her or his main role is to encourage students to be actively involved in their learning so that they are able to construct understanding through their own active engagement and their own previous knowledge. Therefore, the traditional mathematics curriculum model needs to be changed in order to improve students’ learning of mathematics and to enhance their
engagement. To accommodate this change, one approach that can be adopted by the lecturer is informed by constructivism.

Constructivism is a theory about learning. The main concept of constructivism is that learning is an active process of creating knowledge rather than acquiring or transferring knowledge. Constructivism is all about inquiry, exploration, autonomy, and personal expressions of knowledge and creativity. The following principles provide a general framework of constructivism and its relevance for instruction. These principles will be elaborated in Chapter 2: (1) Learners bring unique prior knowledge and beliefs to a learning situation. Each student in a classroom has different background and different ability to learn the same topic. The lecturer should be aware of these differences. (2) Knowledge is constructed uniquely and individually, in multiple ways, through a variety of tools, resources, and contexts. The lecturer should familiarise students with various teaching and learning strategies. (3) Learning is both an active and reflective process. (4) Learning is developmental. We make sense of our world by assimilating, accommodating, or rejecting new information. (5) Social interaction introduces multiple perspectives in learning. (6) Learning is internally controlled and mediated by the learner (Technology Assistance Program, 1998).

The Constructivist theory can be summarized in a single statement: Knowledge is constructed in the mind of the learner (Bodner, 1986). This theory suggests that, to the extent that the individuals’ understandings are built from their unique web of prior concepts and their current subjective experiences. Teachers or lecturers should not attempt to transfer their knowledge into their students’ minds. The learner must actively engage in problem situations in order to build understandings which are an extension of, and later become an integral part of, his or her cognitive web (Schifter & Simon, 1992).

Classroom activities are an important aspect of the lecturers’ task in the teaching and learning process based on the constructivist approach where the lecturer acts as a facilitator (Copley, 1992). The lecturer plans the scenario on how the
teaching and learning will be conducted. There is no fixed pattern that should be followed by a lecturer for a constructivist classroom, and teaching practices based on constructivism are varied and flexible. However, there are substantial similarities across constructivist classrooms, namely students are actively engaged, are conscious of their own learning and are able to work collaboratively to solve problems that have real meaning for them. In short, in a constructivism classroom, learning is something a student does - not something that is done to the student (Technology Assistance Program, 1998).

One of the teaching models that can be selected to implement the instructional treatments based on constructivism is the Activity, Classroom-discussion, Exercises (ACE) teaching cycle approach (Dubinsky, 2001). This approach facilitates students to acquire a variety of experiences in learning through various sources and activities. The model encourages students to be involved in three stages of learning; before class, in class, and after class. The first step of the cycle (Activity) occurs before class. The lecturer gives students the opportunity to carry out an activity that relates to the topics that will be discussed in the classroom. In this study, I used concept maps as an activity before class. Students were asked to create concept maps about the topic. This activity was intended to encourage students to learn and construct their understanding about the topics. In class, the next step is Classroom discussion, provides a social context in which students can work together to solve their problems. After class, students were given opportunity to do assigned homework as the ‘Exercise’ component of ACE. In this part, students practised mathematics problem solving and reflected on their solution method to enhance their understanding. The use of the ACE teaching cycle as an approach in the teaching and learning process of the Elementary Linear Algebra course is expected to produce a positive effect on students’ engagement and learning.
1.3 Objective of the Research

The primary objective of the research is to improve teaching and learning by using the ACE teaching cycle as a teaching approach at Padang State University. The use of this strategy is expected to more effectively prepare pre-service teachers to become school teachers in the future. This expectation is the same way as that of the Indonesian government which desires to improve the quality of the education system in Indonesia through improvement in the quality of teachers (Depdiknas, 2005). The result of this study is expected to contribute to the improvement of teacher quality.

Specifically, the aims of this research are; 1) to investigate the effect of implementation of the ACE teaching cycle in the Elementary Linear Algebra course on students’ engagement, 2) to investigate the effect of implementation of the ACE teaching cycle in the Elementary Linear Algebra course on students’ learning, and 3) to investigate the possibilities and the limitations of the implementation of the ACE teaching cycle in the Elementary linear Algebra course.

1.4 Research Questions

Three research questions below address the purpose of this study.

*Research Question 1*

What are the effects of the implementation of the ACE teaching cycle in the Elementary Linear Algebra course in Padang State University on students’ engagement?

The student engagement in the classroom was investigated through the interrelatedness of three domains namely, cognitive engagement, affective engagement and behavioural engagement.
Research Question 2

What are the effects of the implementation of the ACE teaching cycle in Elementary Linear Algebra course in Padang State University on students’ learning?

The students’ learning was investigated through students’ understanding of the concepts and procedures, students’ abilities in problem solving and students’ abilities in communication.

Research Question 3

What are the possibilities and the limitations of the implementation of the ACE teaching cycle in the Elementary Linear Algebra course in Padang State University?

This research question attempts to identify the strengths and the weaknesses of the implementation of the ACE teaching cycle approach in the Elementary Linear Algebra course. This attempt is useful for the application of the approach in the future and to ascertain the strengths that can be sustained and the weakness that need to be taken into account in future plans to implement the approach.

1.5 Significance of the Study

This research is the first study of the use of the ACE teaching cycle as a teaching and learning strategy in the Elementary Linear Algebra course in Indonesia. Hence, this study is significant for several reasons.

First, the focus of the teaching and learning process in this study are the students (student-centred learning) and the approach that was adopted by the lecturer was informed by the constructivist theory. This teaching and learning approach encourages students to be actively involved in the learning process and is expected to improve students’ independence in learning. Teaching and learning using this approach will give the opportunity for students to acquire various
experiences through several learning activities in and outside the classroom. Beside this, students are also expected to have the opportunity to learn the mathematics topics through various sources, not only from the lecturers but also from textbooks, friends, and other sources.

Second, the use of the ACE teaching cycle should help students to achieve the expected outcomes of their learning. This strategy also gives opportunities for students to develop better mathematics knowledge. The knowledge would be useful for their career as mathematics teachers in the future. Through learning using this approach, students are expected to learn mathematics concepts and procedures intensively, to learn to communicate mathematically, to become efficient mathematics problems solvers and to become more engaged in the teaching and learning process of mathematics.

Third, the use of this approach involves students working in groups through cooperative learning. Cooperative learning encourages active participation in learning and collaborative behaviour by developing social and academic skills. Cooperative learning provides opportunities for students to practice and refine their negotiating, organising and communication skills, define issues and problems and develop ways of solving them including collecting and interpreting evidence, hypothesising, testing and re-evaluating (Hopkins & Harris, 2002). Among the benefits of using cooperative learning are increased knowledge and skills, increased conceptual understanding, improved attitude or motivation, improved communication and social skills (Davidson & Kroll, 1991). This activity gives the students the opportunity to socialize, help each other, and improve their knowledge and skills.

Fourth, through this study students have opportunities to be involved in the research process. All participants in this study were prospective teachers. They will be involved in a career that requires continuous professional development. Teachers should have the ability to evaluate and to overcome the problems that arise in their teaching practices. In this respect, one of the abilities that should be
possessed by the teachers is the ability to be engaged in classroom action research. The action research will give teachers the opportunity to develop their professional career. For teachers’ professional development in Indonesia, the government has encouraged teachers at all levels to be able to do action research with financial support and various activities such as trainings, workshops and seminars. However, the government effort has not produced the optimal result. Not many teachers have used action research as a part of their professional career. This condition is due to their limited knowledge about action research and their limited experience in action research activities (Bustari, 2011). So, students as prospective teachers benefit from their involvement in this study which uses action research as a methodology. Their involvement is a valuable experience for those who are preparing themselves to become mathematics teachers.

Finally, as a lecturer-researcher, this study will allow for increased self-reflection on teaching and learning using the ACE teaching cycle strategy. This reflection has been a valuable experience in my teaching practice and in improving students’ learning. This study gives me opportunities to evaluate my teaching practice and to overcome the problems that arise. So, I have the opportunity to improve my teaching practice by studying the problems or issues, reflecting on these issues, collecting and analysing data, and implementing changes based on the findings and experiences.

1.6 Thesis Structure
The structure of the thesis is desired to improve the readability and cohesion of the final report. This section briefly describes the contents of each chapter in this thesis.

*Chapter 1 – Rationale of the Study*

Chapter 1 presents the background and rationale of the study. In this chapter, the objectives of the study are outlined, the research questions posed, and the significance of the study is discussed.
Chapter 2 – Literature Review

The purpose of the chapter 2 is to review the research literature that is relevant to the study. It provides the rationale for the various aspect of the research and its implementation. This chapter presents a review of the literature which was related to: 1) the ACE teaching cycle that was used as an approach in teaching and learning of the Elementary Linear Algebra course in this study, 2) constructivist theory - the teaching and learning principles upon which ACE teaching cycle was based, 3) concept maps - this study used concept maps as a learning activity for students and as a source of data for the researcher, 4) cooperative learning - this strategy was used in the teaching and learning process in this study, 5) students’ reflective journals - this was one of the assignments that students were required to and was used as a source of data in this study, 6) students’ engagement in the mathematics classroom - this was a key factor in investigating the effects of the use of the ACE teaching cycle, and 7) students’ achievement in mathematics - another key factor of investigation in this study.

Chapter 3 – Methodology

Chapter 3 presents the research approach that was used in this study. An action research methodology was used, with mixed methods of data collection and analysis. A total of 37 students were enrolled in Elementary Linear Algebra course in the January-June 2011 semester in Padang State University, West Sumatera, Indonesia. In this study, the position of the researcher was as a lecturer. This chapter also contains a description of the approaches taken to ensure trustworthiness of the study and the ethical issues that were addressed within the study.

Chapter 4 – Finding and Discussion

Chapter 4 presents the data analysis and discusses the findings from the qualitative and quantitative data. The qualitative data emerged from focus group interviews, students’ reflective journals, mathematics concept maps and classroom
observations. Meanwhile, the quantitative data emerged from a questionnaire. The focus of this data analysis is to shed some light on all the research questions.

Chapter 5 – Conclusion

Chapter 5 presents a summary of the findings by addressing each of the research questions outlined in chapter 1. This chapter also provides a discussion of the results, implications of the study, the limitations, and recommendations for further research.

1.7 Summary of the Chapter

This study arose from the need to improve students’ mathematics learning and their engagement in the classroom. To achieve this need, I have implemented the ACE teaching cycle as a strategy in my teaching practice in the Elementary Linear Algebra course in the Mathematics Department of Padang State University. The main aims of this study are: 1) to investigate the effects of implementing the ACE teaching cycle in the Elementary linear Algebra course on students’ engagement, 2) to investigate the effects of implementing the ACE teaching cycle in the Elementary linear Algebra course on students’ learning, 3) to investigate the possibilities and the limitations of the implementation of the ACE teaching cycle in the Elementary linear Algebra course.

This chapter has presented the background and rationale of the study, the research purpose, and research questions. As well, the significance of the study and structure of the thesis are also presented. The next chapter presents the literature review relating to the ACE teaching cycle approach, constructivist theory, concept maps, cooperative learning, students’ reflective journals, students’ engagement in the mathematics classroom, and students’ achievement in mathematics.
CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The major objective of this research is to develop, implement, and evaluate the use of the Activity, Classroom discussion, and Exercise (ACE) teaching cycle in an Elementary Linear Algebra course. The purpose of this chapter is to discuss in depth the constructs used in this research and outline the knowledge provided by previous research relevant to the study.

This chapter contains ten sections. Section 2.2 discusses teaching mathematics in colleges. This study was done on the teaching and learning process at university level, so this section would be relevant to lecturers teaching mathematics in colleges. Section 2.3 explains the ACE teaching cycle that was used as an approach in teaching and learning an Elementary Linear Algebra course. Section 2.4 addresses the constructivist theory as the teaching and learning process that was implemented based on this theory. Section 2.5 discusses concept maps, which were used as a learning activity for students and as a source of data for the study. Section 2.6 talks about cooperative learning, a strategy which was used in the teaching and learning process in this study. Section 2.7 discusses students’ reflective journals, which was one of the assignments that students were required to complete and was used as a source of data in this study. Section 2.8 deals with students’ engagement in the mathematics classroom that was a key factor in investigating the effect of the use of the ACE teaching cycle. Section 2.9 discusses students’ learning in mathematics, another key factor in this study. Finally, section 2.10 is summary of chapter 2.
2.2 Teaching Mathematics in Teacher Training Colleges

Teacher training colleges are where pre-service teachers can acquire the knowledge and skills that will equip them for meeting the challenges of their future careers. The knowledge and skills that are provided to prospective mathematics teachers are not only the content knowledge and skills about mathematics but also the pedagogical content knowledge so that they can be capable mathematics teachers (Livy & Vale, 2011). According to Schulman (1998) pedagogical content knowledge is a kind of knowledge that relates to the ways the teacher represents and formulates their knowledge when teaching. Mathematical knowledge and pedagogical knowledge are important dimensions that proficient mathematics teachers require (Livy & Vale, 2011; Ma, 1999).

Teaching mathematics in college is to prepare students to be able to use mathematics in their careers, because college is a bridge that connects students to the world of work. However, equipping students with good mathematics mastery is not easy. One of the factors that makes it difficult for students to master mathematics is their inadequate mathematics skills (Taplin, 1998), thus making it difficult for them to understand mathematics concepts because most concepts in mathematics relate to abstract ideas that are connected each other. Students will face difficulties in studying mathematics if they were to lose the link between concepts. According Brijlall and Maharaj (2009), many students perform poorly in mathematics because they are unable to adequately handle information given in symbolic form which represent objects, for example mathematical expressions, equations and functions. Besides these factors a high percentage of students have a static view about mathematics (Maharaj, 2011). Students with such a view will have difficulty in learning mathematics in depth and to engage in the teaching and learning process.

Other problem of teaching mathematics to prospective mathematics teachers is the teaching and learning process that is still conducted conventionally (teacher-centred approach) in some teachers’ college. Such a teaching and learning process
does not provide the optimal conditions for students to be able to be good teacher. In the teacher-centred approach classroom, students’ dependence on the lecturer to acquire knowledge and skills is very high and students’ opportunity to interact and socialize among themselves is very low. The prospective teachers must have the opportunity to develop their ability to become independent learners. This ability will help them to grow better in their career as teachers. In college, students must also have the opportunity to develop their ability in socializing, discussing, and sharing ideas between themselves because these activities are very important for supporting their careers in the future (Dikici, 2006; Pedro & Brunheira, 2001).

The conventional teaching model needs to be changed in order to improve both the quality of the teaching practice and student learning of mathematics. The focus of the teaching and learning process must be the students (student-centred learning). To accommodate this, one approach that can be adopted by the lecturer is informed by constructivism. This theory suggests that, to the extent that individuals’ understandings are built from their unique web of prior concepts and their current subjective experience, teachers or lecturers cannot transfer their knowledge into their students’ minds. The learner must actively engage in problem solving situations in order to build understandings which are an extension of, and later become an integral part of, his or her cognitive web (Schifter & Simon, 1992). Constructivist theory can be summarized in a single statement: Knowledge is constructed in the mind of the learner (Bodner, 1986).

In education, there are several instructional models that are based on the constructivist approach. Two of them are the 5Es (Engagement, Exploration, Explanation, Elaboration, and Evaluation) instructional model and the ACE (Activity, Classroom discussion, and Exercise) teaching cycle. According to Bybee et al. (2006) 5E is an instructional model that begins with students’ current knowledge and their new ideas that relate to the current knowledge. The connection between prior knowledge and new ideas gradually forms concepts. The next step involves direct instruction where the teacher systematically explains ideas that the students could not be expected to discover. Finally, the teacher
provides opportunities for the students to demonstrate their understanding. For practicality in implementation, this instructional model is divided into 5 phases namely, Engagement, Exploration, Explanation, Elaboration, and Evaluation. This 5Es teaching model is useful in facilitating students to be able to construct their own understanding based on their previous knowledge and their experiences in learning the topics. The 5Es instructional model is widely used by science teachers at all levels of school (Enhencing Education, 2012).

According to Dubinsky (1995) the ACE teaching cycle is a learning model that begins with students’ Activity before class, then Classroom discussion, and finally students do Exercise after class. The ACE teaching cycle was developed to accommodate teaching and learning mathematics at university level (Arnawa, 2006; Dubinsky, 1995). The ACE teaching cycle encourages students to do learning activities before class, facilitates students to discuss in the class, and encourages students to do exercise as homework after class. As a mathematics lecturer at a teachers’ college I would tend to choose the ACE teaching cycle as an approach to my teaching practice because the approach requires students’ independence in learning so that the approach is suitable for college students. The section 2.3 below will discuss the ACE teaching cycle which was used as a teaching approach in this study more detail.

2.3 The Activity, Classroom Discussion, and Exercise (ACE) Teaching Cycle Approach

Based on my experiences, most of the teaching and learning processes in my university (Padang State University, Indonesia) still run conventionally where lecturers are the main participants in teacher-centred teaching (Nesmith, 2008). The teaching and learning process almost follows the same pattern for each session. Generally, mathematics lecturers follow four teaching steps when they teach mathematics: explaining the materials, giving examples, asking students to do exercises and giving homework.
The main focus of the lecturer in the conventional teaching and learning model is the completion of the given curriculum. Through this model, students cannot get a variety of experiences in the learning process. Further, their learning outcomes might be restricted to knowledge of content. According to Sumarmo (2000), the teaching and learning mathematics process should accommodate students to access four terms in learning: learning *to know*, learning *to do*, learning *to be*, and learning *to live in peace and harmony*.

In the process of learning *to know*, students develop in-depth understanding of mathematics concepts, axioms, definitions, theorems, and their applications. According to Ma ("Assessing The Relationship Between Attitude Toward Mathematics and Achievement in Mathematics: A Meta-Analysis," 1997), there are two important issues in learning *to know*: the quality of understanding of the concept and the ability of using the concept. The lecturer has the responsibility to facilitate students’ in-depth understanding of mathematics concepts. For this purpose, the lecturer has to choose an approach that enables students to be actively involved in constructing their own mathematics knowledge (Alsup, 2004). By espousing a constructivist view of mathematics learning in which the lecturer does not transmit mathematics knowledge directly to students, the students are able construct their knowledge through their learning experiences (Alsup, 2004).

Through the process of learning *to do*, students are encouraged to actively learn the mathematics processes to stimulate their intellectual development. In this case, teachers/lecturers have to design the instructions of teaching and learning, as well as prepare resources and problems that can be accessed by students. Here, the teacher acts as a facilitator. The teacher has to pay attention to what students already know prior to commencing a new topic. Appropriate mathematics problems have to be chosen so that students can get the optimal learning experience (Galovich, 1995).
In the process of learning to be, students achieve appreciation of mathematics. Their appreciation can be seen through their behaviour through conformity with school and classroom procedures, becoming involved in school activities, and taking part in school governance. All of these aspects will support students in becoming self-learners and to develop their understanding of mathematics.

Through the process of learning to live together in peace and harmony, students have opportunities to socialize, communicate, and respect each other. Here, they learn how to share ideas, how to argue, and how to respect someone’s opinions. This can be achieved through cooperative learning (Slavin, 1995).

The traditional teacher-centred model needs to be changed in order to improve both the quality of the teaching practice and student learning of mathematics. The focus of the teaching and learning process must be the students in student-centred learning. To accommodate this model, one approach for the teaching and learning process that can be adopted by the lecturer is informed by constructivism. According to Driscoll (2000) and Fosnot (1996) the constructivist approach in the teaching and learning process facilitates student thinking, active learning, and highlights students’ ability in communication, reasoning and conceptual understanding as presented in the National Council of Teachers of Mathematics’ Principles and Standards for School Mathematics (NCTM, 2000).

One of the teaching models that can be used to implement the instructional treatments based on constructivism is called the ACE (Activity, Classroom Discussion, Exercises) teaching cycle (Dubinsky, 2001). This model was first introduced by Dubinsky (1995) to help students’ learning of mathematics through the use of computer programming. In this design, Dubinsky broke up the course into sections, each of which was conducted in one week. During the week, the class met on some days in the computer laboratory and on other days in a normal classroom in which there were no computers. Homework was done outside of classroom. Dubinsky (1995) implemented the three components of the model as follows:
Activities: the class met in a computer laboratory where students worked in teams on computer tasks. The lab assignments were generally too long to finish during the scheduled lab time and students were expected to come to the lab when it was open or work on their personal computers, or use other labs to complete the assignment (Dubinsky, 1995). This activity gave opportunity for students to explore their previous knowledge which related to the topics they were studying.

Classroom discussion: the class met in a classroom where students worked in groups to perform paper and pencil tasks based on the computer activities in the lab. The instructor led inter-group discussions designed to give students an opportunity to reflect on the tasks they had been working on. On occasion, the instructor would provide definitions, explanations, and an overview to tie together what the students had been thinking about (Dubinsky, 1995). Through the discussion in the classroom students had opportunities to share their ideas so that they would have better understanding of the concepts.

Exercises: relatively traditional exercises were assigned for students to work on in teams. These were expected to be as homework that was in addition to the lab assignment. The purpose of the exercise was for students to reinforce the ideas they had constructed, to use the mathematics they had learned and, on occasion, to begin thinking about the content that will be studied later (Dubinsky, 1995).

Asiala and his colleagues implemented the ACE teaching cycle in a Calculus course at Midwestern University in USA. They particularly wanted to see the effect of the strategy on students’ graphical understanding of a function and its derivative. This was a comparative study. The researchers adopted the stages that were proposed by Dubinsky (1995). Activities: students were given the task that related to the topics which would be discussed in the class. They completed the task using ISETL (Interactive Set Language) mathematics programming software. Classroom discussion: students held discussions in the classroom to solve the issues that they faced in learning the topics. Exercises: this stage was intended to help students reinforce the knowledge they had constructed (Asiala, Cottrill, et al., 1997). In doing their research, they compared students’ performance in the
experimental class with students’ performance in the control class that was taught traditionally (the control group). Students from the two groups were interviewed about their understanding on the derivative of a function at a point graphically. The result of this study was that students who followed the course that was based on ACE teaching cycle approach had more success in developing a graphical understanding of a function and its derivative than students in the control group. The ACE teaching cycle approach was reasonably effective in helping students develop a relatively strong process conception of function and a graphical understanding of the derivative (Asiala, Cottrill, et al., 1997).

Trigueros, Oktac, and Manzanero (2007) used the ACE teaching cycle as an approach in their research on a Linear Algebra course during one semester at an undergraduate institution in Mexico. The strategy that they used to implement the ACE teaching cycle was almost the same as the strategy that was used by Asiala and his colleagues above. In this study, Trigueros and his colleagues proposed the CAS (Computer Algebra System) Maple mathematics software that was used by students to complete their task before class. In their research, they did interview students twice (at the beginning and at the end of the study) to collect data about students’ ability in mathematics. In the first interview, the researchers found that the students could be divided into two groups according to their responses to the questions: those who displayed good background knowledge from elementary algebra courses, and those who did not possess such background knowledge. The results of the second interview confirmed that the use of the approach was effective only with students who had good background of elementary algebra. Good understanding of elementary algebra seems to be really important for students to learn the concepts related to systems of equations in the linear algebra course (Trigueros et al., 2007).

Arnawa (2006) had also conducted research using the ACE teaching cycle as a strategy in his teaching practice at Andalas University in Indonesia. The main approach that he used to implement the ACE teaching cycle was almost the same as the strategy that was used by Asiala et al. (1997). He also used the ISETL
mathematics programming software for activities in the computer laboratory and cooperative group learning for discussion in the classroom. His research aim was to investigate the differences between students who attended the class using the ACE teaching cycle approach (experimental group) and students who attended the class using a traditional approach (control group) in their ability to prove theorems and students’ attitude in learning abstract algebra. The researcher obtained data from a mathematics test and an attitudes questionnaire at the end of his study to investigate the differences, if any. The result of his research was that the students who attended the class based on the ACE teaching cycle approach were able to prove theorems significantly better than students from the traditional class. Meanwhile, his study on students’ attitudes revealed that students who attended the class using the ACE teaching cycle approach had more positive attitudes towards the teaching and learning process of abstract algebra than students who attended the traditional class (Arnawa, 2006). In his study, Arnawa used 8 aspects (scales) to measure students attitudes namely, confidence (A), anxiety (B), attitude on the usefulness of abstract algebra (C), attitude for success (D), encouragement for success (E), perception on lecturer support (F), perception on learning in small groups (G), and perceptions about the lecturer’s and students’ role in the teaching and learning process (H). Table 2.1 below presents the result of mean value of the eight scales of the attitude questionnaire on the experimental group and control group.

<table>
<thead>
<tr>
<th>Group</th>
<th>Means of Attitude Scale</th>
<th>Average Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Experiment</td>
<td>3.98</td>
<td>3.64</td>
</tr>
<tr>
<td>Traditional</td>
<td>3.52</td>
<td>3.46</td>
</tr>
</tbody>
</table>


In implementing the ACE teaching cycle, researchers of the three studies used computer technology in teaching and learning mathematics. Students were encouraged to learn the contents to be discussed in the classroom using
mathematics software. Through the use of the software, students were expected to be able to construct their understanding.

The studies focused on using technology in learning of content. They required a computer laboratory, the availability of mathematics software, and skill in using computers. If any of these conditions were not met then the implementation of the ACE teaching cycle as applied by the above three studies would not have been successful. We need an alternative so that the application of the ACE teaching cycle does not depend on computer technology.

In this study, the scenario that I used to implement the ACE teaching cycle in an Elementary Linear Algebra course involved the following three stages: (1) Activity: Asiala, et al. (1997), Trigueros et al. (2007), and Arnawa (2006) used mathematics programming language like ISETL and CAS Maple as students’ activities before class. In this study, I used concept maps as students’ activity before class. Students worked together in small groups (two or three members) to create concept maps. The main focus of this activity was to encourage students to explore their previous knowledge in order to build new desired mental constructions (Asiala, Cottrill, et al., 1997; Dubinsky, 2001). (2) Classroom discussion: students used cooperative group learning. They were grouped into permanent teams consisting of four, five, or six members each. In the group, they discussed solving of mathematics problems. This provided a social context in which the students could work together to solve mathematics problems. This classroom discussion was no different from what had been done by Asiala, Trigueros, and Arnawa. (3) Exercises: students were given homework to be completed outside of class. There were two kinds of homework which they had to complete traditional exercises and a reflective journal. This was different from the three previous studies above that used traditional exercises as homework but did not require students to complete reflective journals. In this study, students completed traditional exercises in small groups (same groups as when they created the concept maps), while to complete the reflective journal students wrote
individually. The ACE teaching cycle is an instructional model that based on constructivism theory. The next section will elaborate on this theory.

2.4 Constructivism

The discussion about constructivism in this section is intended to provide the theoretical basis for the ACE model used in this study. The instructional model that has been used for the teaching and learning process in this study is based on many principles promoted in constructivism. Constructivism is a theory about learning based on the view that students are active knowledge seekers powered by their curiosity (Sunal & Hass, 2002). The main concept of constructivism is that learning is an active process of creating knowledge by students, where the students construct her or his knowledge to build understanding (Jadallah, 2000; Jonassen, Howland, Moore, & Marra, 2003). The Constructivist theory can be summarized in this statement: Learners construct knowledge in their mind through the learning which is done by themselves (Bodner, 1986; Sjoberg, 2010).

Constructivist theory suggests that, to the extent that individuals’ understandings are built from their unique web of prior concepts and their current subjective experiences, teachers cannot transfer their knowledge into their learners’ minds. The learner must actively engage in problem situations in order to build understandings which are an extension of, and later become an integral part of, his or her cognitive web (Schifter & Simon, 1992). According to the Technology Assistance Program (1998) constructivism is all about inquiry, exploration, autonomy, and personal expressions of knowledge and creativity. In the next paragraphs below are principles that provide a general framework of constructivism and its relevance for instruction.

Learners bring unique prior knowledge and beliefs to a learning situation. Each student in a classroom has different background and different ability to learn the same topic. The prior knowledge, beliefs and experiences of a learner are the foundations for learning; they provide opportunities for personal connection with
new content (Southwest Educational Development Laboratory, 1999). There is widespread agreement that prior knowledge influences learning, and that students construct concepts from prior knowledge. To help students make the most of a new experience, teachers/lecturers need to understand how prior knowledge and beliefs affect learning (Roschelle, 1995).

Knowledge is built uniquely and individually in multiple ways through a collection of tools, resources, and contexts. Constructivist learning theory informs us that students learn in a variety of ways. The more opportunities students have, and the more actively engaged they are, the deeper their understanding (Southwest Educational Development Laboratory, 1999). So, to maximize students’ engagement and achievement in learning educators should provide them with various teaching and learning strategies, resources, and tools.

Learning is both an active and reflective process. Students are involved in active learning so that they have opportunities to achieve meaningful experiences. In active learning, students also have opportunities to reflect on their learning process. Action and reflection must be present in students’ learning to support the construction of new knowledge (Southwest Educational Development Laboratory, 1999).

Learning is a process of accommodation, assimilation, or rejection to construct new conceptual structure. Students are surrounded by a lot of information, ideas, and other stimuli that provide input for thought and understanding. Students have the opportunity to filter the new ideas or information. If new ideas match the students’ existing knowledge, they are easily assimilated. If they do not match, the students must determine how to accommodate them, either by forming new understanding, or rejecting the idea (Adams & Burns, 1999; Southwest Educational Development Laboratory, 1999).

Social interaction introduces multiple perspectives on learning through reflection, collaboration, negotiation and shared meaning. During social interaction students
have opportunities to communicate with each other. Through verbal representation of thoughts students are able to speak about ideas, to clarify procedures, to float a theory, etc. These activities enhance students’ insight in learning (Adams & Burns, 1999).

Learning is internally controlled and mediated by the learner. Knowledge construction occurs internally in the private domain of each learner. Learners receive the knowledge, process it, and build new understandings (Adams & Burns, 1999; Technology Assistance Program, 1998).

There is no fixed pattern that should be followed by a lecturer in a constructivist classroom, and teaching practices based on constructivism are varied and flexible. However, there are significant commonalities across constructivist classrooms, namely students are engaged, active, and conscious of their own learning and can work collaboratively to solve authentic problems that have real meaning for them. In short, in a constructivist classroom, learning is something a student does - not something that is done to the student (Technology Assistance Program, 1998).

The ACE teaching cycle model that was implemented in this study fulfilled the above principles. During the Activity (concept map activity) stage students accommodates to construct their understanding individually and uniquely through exploring their prior knowledge. According to Novak (1990), Alansari (2010), and Spinner (2002) there are three basic objectives of using concept maps in learning: facilitation of meaningful learning, promoting critical thinking, and determining prior knowledge and alternative conceptions. Through Classroom discussion, students have the opportunity to interact with others so that they have multiple perspectives on learning. Through doing Exercises they have the opportunity to reflect on what they have learnt.

The teaching and learning process that is based on constructivism requires the lecturer to become a facilitator of knowledge. The lecturer’s role is to create experiences for learners and then guide them through these experiences. This
allows the learners to construct their own knowledge through exploration (Doolittle, 2001; Rice & Wilson, 1999).

2.5 Engagement in the Mathematics Classroom

According to Elmore (1990) student engagement in the teaching and learning process is a significant goal for education. Student engagement in learning leads to achievement and influences to students’ cognitive and social development (Finn, 1993; Newmann, 1992). Students who are engaged with the learning process are more likely to be involved in learning seriously, to get meaningful experience, and to pursue higher education (Marks, 2000). However, student disengagement in learning is still a problem in education. Disengagement leads to reducing the variety of knowledge and information that can be absorbed by students in learning. In addition, students who are disengaged in learning limit their capacity to understand learning experiences (Attard, 2011).

Newmann and Lamborn (1992) defined engagement as students’ psychological investment in and effort directed towards learning, understanding, or mastering the knowledge, skills, or crafts that academic work is intended to promote. D’mello (2008) described engagement as student’s willingness, need, desire and compulsion to participate in, and be successful in, the learning process. It is an important issue in teaching because it affects how much students learn on a daily basis. The engagement depends greatly on students’ interest and the teacher’s ability to create an environment that invites students to learn (D’mello, 2008; Tomlinson, 2002).

Student engagement is generally recognized as one of the better predictors of learning (Carini, Kuh, & Klein, 2006; Caulfield, 2010). So, creating the teaching strategy that improve students engagement will lead to increased student learning, which is the main goal for both students and teachers. The challenge for a teacher is to create a setting and activities that students find engaging and that are able to advance their proficiency in abilities that they find useful. Such instruction helps
learners to find the curriculum comprehensible and stimulating, inclusive and promotes a supportive classroom (Cole, 1996).

Tomlinson (2002) expresses five important criteria for a student’s engagement in the classroom: (1) Purpose - students need to know what they do at school, realise the significance in it and know that the work they do makes a difference to the world. Knowing the importance of the topics that they learn would encourage them to become actively involved in the teaching and learning process. (2) Contribution - each student needs to feel that they can make a difference. They want to bring something unique and valuable for other friends in the class. The opportunity to be able to contribute in the classroom will encourage them to stay engaged in the teaching and learning process. (3) Affirmation - is important for students to know that they are accepted, safe, and understood. This condition will encourage students to feel comfortable and give them the opportunity to learn better in the classroom. (5) Power - students need to believe that the knowledge which they have acquired is useful and will assist them on their journey beyond the classroom. The belief that the topics which they are learning will be useful in their lives will encourage them to be more diligent in learning. (5) Challenge – the tasks need to stretch the students and they need to know when they work hard they generally succeed, that they are accountable for their own growth and that they are able to contribute to the growth of others. The awareness that they have to develop will encourage them to be more involved in the learning activities.

In this study, the degree of student engagement in the classroom would be investigated through three domains namely, cognitive engagement, affective engagement and behavioural engagement (Caulfield, 2010; Chapman, 2003).

Cognitive engagement is closely related to academic involvement or approaches to learning involve the ideas of investment, recognition of the value of learning and a willingness to go beyond the minimum requirement (Attard, 2011; Fredricks, Blumenfeld, & Paris, 2004). According to Biggs (1978) and Kong et al. (2003) there are three approaches to learning, namely; surface strategy (closely
associated with lower levels of learning outcomes – memorisation, practising, handling tests), deep strategy (closely related to higher levels of learning outcomes – understanding the question, summarising what is learnt, connecting knowledge with the old ways of learning), and reliance (relying on teachers) Behavioural engagement is closely related to student participation in the classroom. Active participation in the classroom is demonstrated by compliance with classroom procedures, taking initiative in the group and classroom, becoming involved in classroom activities, asking questions, regularly attending class, and comprehensively completing assignments (Chapman, 2003; Skinner & Belmont, 1993).

Affective engagement is closely related to students’ reactions to the learning environment (school, teachers, peers, and academic curriculum) that influence willingness to become involved in school activities (Attard, 2011; Chapman, 2003). According to Miserandino (1996) and Kong et al. (2003) students’ affective engagement can be seen through four dimensions namely, interest, achievement orientation, anxiety and frustration.

In terms of engagement with mathematics, engagement occurs when learners are procedurally engaged in the classroom, actively learning mathematics, participating in all tasks, and hold the view that studying mathematics is useful, valuable, and worthwhile both inside and outside of the classroom (Attard, 2011). The above explanation revealed that the engagement associated with students’ involvement in the mathematics learning process is dependent on behavioural, affective, and cognitive aspects of learning.

2.6 Students’ Learning in Mathematics

Traditionally, people tend to have the view that the result of students’ learning in mathematics can be seen through their achievement in mathematics tests. This view is demonstrated by the extensive use of tests by educators in their practices. The use of tests to evaluate students’ performance in learning has many
weaknesses. According to Stake (1999) mathematics test scores are not a basis for indicating how well students have become successful in learning mathematics. They do not directly measure how well educated in mathematics the student is becoming. They do not identify the cognitive structures of students’ thinking.

In fact, students’ learning in mathematics can be obtained through a variety of ways. One of them is through authentic assessment. This kind of assessment looks directly at students’ work and their performance as a result of their mathematics learning. Such assessments include students’ written tasks, students’ solution of problems, students’ presentations, students’ experiments, and teachers’ classroom observations (Darling-Hammond, Ancess, & Falk, 1995).

According to Battista (1999) the focus of students’ learning in mathematics must be on problem solving, mathematical reasoning, justifying ideas, and independently learning new ideas. Students have to be given opportunities to develop their communication ability in mathematics or to increase their ability to read, write, and discuss mathematics. The National Council of Teachers of Mathematics (NCTM) has identified five process standards in teaching and learning mathematics: problem solving, reasoning and proof, communication, connection and representation. The result of students’ learning in mathematics can be achieved with active involvement in learning using these processes. These processes enable them to deepen mathematical understanding that leads to increasingly sophisticated abilities required to meet mathematical challenges in meaningful ways (NCTM, 2000; The Oklahoma State, 2009).

Students’ activities that relate to the problem solving process standard are: (1) use problem solving approaches, (2) formulating problems in everyday life and mathematical situations, (3) developing and applying strategies to solve a variety of routine and non-routine problems, (4) verifying and interpreting results with respect to the original problem, and (5) distinguishing between necessary and irrelevant information in solving problems (The Oklahoma State, 2009).
Students’ activities that relate to the communication process are: (1) expressing mathematics ideas coherently and clearly to peers, teachers, and others, (2) extending mathematics knowledge by considering the thinking and strategies of others, (3) relating pictures, diagrams, and symbols to mathematics ideas, (4) representing, discussing, writing and reading mathematics ideas and concepts (The Oklahoma State, 2009).

Students’ activities that relate to reasoning process standard are: explaining mathematics situations using patterns and relationships, demonstrating thinking processes using a variety of age-appropriate materials and reasoning processes, making predictions and drawing conclusions about mathematics ideas and concepts (The Oklahoma State, 2009).

Students’ activities that relate to connecting between process standards are: (1) relating various concrete and pictorial models of concepts and procedures to one another, (2) linking concepts to procedures and eventually to symbolic notations, (3) recognizing the relationship among different topics within mathematics, (4) using mathematics strategies to solve problems that relate to other curriculum areas and the real world (The Oklahoma State, 2009).

Students’ activities that relate to the representation of process standards are: (1) creating and using a variety of representations appropriately and with flexibility to organize, record, communicate mathematics ideas, (2) using representations to model and interpret physical, social, and mathematical situations (The Oklahoma State, 2009).

In this study, the focus of students’ learning was to observe students’ understanding of concepts and procedures, students’ ability in problem solving, and students’ ability in communication. To evaluate students’ understanding of concepts and procedures, the researcher would use the data from classroom observations, students’ reflective journals, and concept maps. To evaluate students’ ability in problem solving, the researcher would use the data from
classroom observations. To evaluate students’ ability in communication, the researcher would use the data from classroom observations and concept maps.

2.7 Concept Maps

The aim of the discussion about concept mapping in this chapter is to give the theoretical support for their use in this study. Concept maps were used in this study as a students’ activity before class. This activity is an integral part of the ACE teaching cycle which was implemented as an approach in the teaching and learning process. Students were required to create a concept map about the topics that would be discussed in the class. Through this concept map activity students were encouraged to be actively involved in the learning process to enable them to construct their own understandings.

Concept mapping is derived from a constructivist approach to teaching and learning. Concept mapping is a technique used for representing knowledge graphically, where the knowledge that is represented is related to concepts that are interconnected. A concept map consists of nodes and links. The nodes correspond to important terms representing concepts and the links represent the relationship between the concepts (Wange, 2005). The concept map is intended to demonstrate the level of deep understanding of the students through their illustration of connections between concepts (Roberts, 1999).

Concept maps were first introduced by Novak as a research tool. The method of concept mapping has been developed specifically to tap into a learner cognitive structure and to externalise what the learner already knows (Brinkmann, 2005; J D Novak, 1990). Although the primary intention was to use concept mapping in research, it was also found to be a useful tool in the teaching and learning process, helping students to learn.

Concept mapping operates as a tool for helping learners. The main purpose of using concept maps is to help students make sense of their experiences and to construct their own understandings (Brinkmann, 2005; Joseph D. Novak, 2004;
Students would not be able to confidently create a concept map about a topic if they did not have enough experience about that topic; their experience in learning would very helpful to produce a good concept map. In the process of creating the concept map, students also have the opportunity to deepen their understanding of the topic.

Researchers have identified three basic objectives of using concept maps in learning: facilitation of meaningful learning, promoting critical thinking and determining prior knowledge and alternative conceptions of students (Alansari, 2010; J D Novak, 1990; Spinner, 2002). Meaningful learning emphasizes the constructive integration of thinking, feeling, and acting leading to empowerment for commitment and responsibility (Alansari, 2010; Niehaus, 1994). When learners actively construct a complex structure of interconnected ideas or concepts with many levels of hierarchy, branching and cross-linking using a visual tool (like a concept map), they engage in meaningful learning (Alansari, 2010; Quinn, Mintzes, & Laws, 2003).

According to Vacek (2009) the use of concept maps will increase learning and promote the use of various critical thinking abilities such as analysis, interpretation, inference, explanation, and self-regulation. Alansari (2010) also suggested that the activity of creating of concept maps will challenge learners to think more critically. This is possible when in the process of making the concept map students trying to make meaningful connections between concepts that involve their experiences and knowledge.

Concept maps are useful tools for presenting the knowledge held by learners, and also to identify learners’ alternative conceptions (Brinkmann, 2005; J D Novak, 1991). Through creating concept maps learners have opportunities to make various links between the concepts that they have learnt. Student’s prior knowledge and alternative conceptions can be assessed through concept maps which she or he created, and teacher can use it to diagnose students’ understandings (Ross & Munby, 1991). Concept maps help learners to make clear
the main concepts or propositions to be learned and suggest connections between new and previous knowledge (BouJaoude & Attieh, 2008).

The creating of concept maps depends on situations or events that require understanding. Generally, concept maps are developed based on a hierarchical style. Its standard procedure involves defining the topic, identifying and listing the most important or general concepts that are associated with that topic, and then ordering the concepts from the top to the bottom of the map (Alansari, 2010; J D Novak & Gowin, 1984).

There are several ways students can develop concept maps to support their learning process. The first way is through the provision of a fill-in task, where students are given the knowledge structure of the map, a list of concepts, and lists of linking words to use to fill in the slots (Ruiz-Primo, Schultz, Li, & Shavelson, 2001). The second way is through provision of a graph-from-scratch task. Students are required to provide all concepts and linking phrases. This is a low directedness concept maps task. According to Ruiz-Primo et al. (2001) the tasks of map construction that are low in control may provide clearer insight into differences among students’ knowledge structures and give students more opportunities to develop their understanding.

In this study, the task of creating the mathematics concept map that was chosen as an activity before class was a graph-from-scratch task. Through this task to design concept maps students are expected to explore their knowledge and present it in the form of a concept map. This is in line with the main purpose of student activity before class; they must have knowledge of the topics to be discussed in class.

According to Roberts (1999) concept maps can be analysed/evaluated qualitatively or quantitatively. Qualitative analysis can be done to identify students’ misconceptions, understanding, and changes in students’ perceptions over time. With availability of this knowledge, the lecturer has the opportunity to modify her or his teaching focus based on what students need so that the students’
misconceptions can be addressed and students’ understanding can be increased. Quantitative evaluation is usually done for assessment purposes. There is a need to give a score to a concept map; the numerical scores which are given to the concept maps enables a ranking of students but they do not provide all of information available to a lecturer (Roberts, 1999). Both of these analyses can be done to complement each other.

For scoring concept maps, there are several ways that have been used by researchers such as proposed by Novak and Gowin (1984). Their scoring of concept maps is based on the components and structure of the map that are presented by students. For valid propositions they gave 1 point each, for each hierarchy level they gave 5 points, for branching they gave 1 point for each branch, for cross-links they gave 10 points for each valid cross-link, and for examples which are presented by students they gave a score 1 point for each example. This method of scoring provided valuable information about the students’ knowledge structure about the topics although this system of scoring has proven to be time-consuming (Alansari, 2010).

Another method for evaluating a concept map is by comparing the concept map created by a student with the concept map constructed by an expert (Ruiz-Primo & Shavelson, 1996). A teacher or a group of teachers can produce an expert map to compare with students’ concept maps. Lomask, Baron, Greig, and Harrison (1992) described the scoring proportion of students’ concept maps compared with expert an concept map. This proportion was scaled from complete (100%), to substantial (67% - 99%), to partial (33% - 66%), to small (0% - 32%), to none (if the map is irrelevant). Teachers or lecturers can also use a computerized technique to simplify the comparison of the maps. This method has been developed by the Centre for Research on Evaluation, Standards, and Student Testing (CRESST) (Chung, Herl, Klein, O’Neil, & Schacter, 1997) in the US. This computerized scoring system is basically based on proportional matching within limited sets of concepts and linking phrases. For complex maps, the lecturer still needs to score manually.
In this study, the concept maps that were produced by students were analysed qualitatively. Qualitative analysis can be done to identify students’ misconceptions, understandings, and changes in students’ perceptions over time (Roberts, 1999). The analysis was done on content, in terms of the structural complexity, and validity of concept labels and propositions (Afamasaga-Fuata’i, 2009). Using the concept maps, the researcher is able to know how far the students have learnt mathematics in terms of their preparation to discuss the material in the classroom. The lecturer/researcher did not give a judgment (scoring) on each concept map that was originally created by students because the concept maps that were produced by students did not reflect the final outcome of their learning process on a topic. The concept maps task was intended to encourage students to learn the topics which would be discussed in the class.

2.8 Cooperative Learning

The discussion about cooperative learning in this chapter is intended to give theoretical support for their use in this study. The ACE (Activity, Classroom discussion, and Exercise) teaching cycle that was implemented as an approach in the teaching and learning process in this research incorporated cooperative learning as a model for students’ learning in the three stages of the ACE teaching cycle. Students used cooperative learning for the concept maps activity before class, for classroom discussions to solve mathematical problems, and for exercises after class to complete as homework.

Cooperative learning is a model of teaching and learning where students working together in small groups on a collection of academic problems can develop both their social and intellectual skills. It has a powerful potential in raising student achievement because its harnesses the synergy of collective action (Slavin, 1995). According to Davidson and Kroll (1991) cooperative learning is generally understood to be learning that take place in an environment where students in small groups share ideas and work together to complete academic tasks.
Cooperative learning encourages active participation in learning and collaborative behaviour by developing social and academic skills. Cooperative learning gives students the opportunity to practise and refine their negotiating, organising and communication skills, define issues and problems and develop ways of solving them including collecting and interpreting evidence, hypothesising, testing and re-evaluating (Hopkins & Harris, 2002). Among the benefits of using cooperative learning are increased knowledge and skills, increased conceptual understanding, improved attitudes or motivation, improved communication and social skills (Davidson & Kroll, 1991).

Good, Mulryan, and McCaslin (1992) revealed that implementing cooperative learning does not automatically ensure cooperative work and a positive effect on all students. For example, sometimes highly competent students, by exhibiting far more active behaviour, tend to dominate less competent students. Although promoting learners’ activeness in studying through cooperative learning settings seems to be more feasible for high-ability learners, the real challenge remains doing so for low-achieving learners (Leikin & Zaslavsky, 1997).

A main concern among mathematics lecturers/teachers, in term of promoting students’ activeness, is meeting low-achievement students’ need for help in the course of learning mathematics (Leikin & Zaslavsky, 1997). Newman and Goldin (1990) state that students, particularly the low achievers, are reluctant to seek help when they have difficulty in learning. They are most reluctant to ask for help from their friends, mainly for fear of being embarrassed. Besides that, shy students are also reluctant to be actively involved in classroom discussions. However, shy students can be among the brightest and most creative students in the class (A Professional Approach Series, 2013). Lecturers/teachers also need to encourage them to actively participate in the class. Cooperative learning facilitates them to work together in a group so that they have opportunities for sharing ideas and solving their problems.
There is a wide range of strategies for implementing the cooperative learning model. They are all however governed by the following principles: positive interdependence, individual accountability, face-to-face interaction, social skills, and group processing (Johnson, Johnson, & Holubec, 1993).

**Positive interdependence:** each group member feels connected to each other in the attainment of the common goals, and each of them makes a contribution to attain the goals. All members must succeed for the group to succeed. This principle is the central aspect of cooperative learning, if there is no positive interdependence, there is no cooperation (Johnson et al., 1993).

**Individual accountability:** every member of the group is responsible to share their knowledge. All activities in the cooperative learning group must be directed to the improvement of individual understanding, learning together to increase the performance of all individuals of the group. The aim of cooperative learning is to make each member in the group become stronger as an individual (Professional Development Support Teams, 2012).

**Face-to-face interaction:** all members of the group are in a close relationship to help each other and to share resources. Based on this principle, students have the opportunity to explain and teach what they know to friends in their group. Some of the activities that include face-to-face interaction are: teaching each other, orally explaining how to solve problems, checking for understanding, discussing concepts and connecting knowledge. Each of these activities can be structured into group tasks procedures. So, face-to-face interaction ensures that cooperative learning become both a personal support system and an academic support system (Professional Development Support Teams, 2012).

**Social skills:** these skills are specific observable behaviour which aids the achievement of a task. Cooperative learning accommodates students for interacting effectively with others. Human interaction skills that enable groups to function effectively (e.g. taking turns, encouraging, listening, giving help,
clarifying, checking, understanding, probing). Such skills enhance communication, trust, leadership, decision-making, and conflict management (Johnson et al., 1993).

**Group processing:** this involves members reflecting on the group’s task and examines how the group can work effectively and efficiently together. The teacher/lecturer facilitates whole class processing where groups share their reflection with the others. All members of the group can assess their collaborative efforts (Johnson & Johnson, 1993; Professional Development Support Teams, 2012).

In this study, cooperative learning was used by students in creating the concepts maps before class, in solving mathematical problems in the class, and in doing exercise after class. Students were asked to use cooperative learning to complete all tasks. They were encouraged to use cooperative learning by referring to the five principles above.

On concept maps activity before class, students completed the task of concept maps in small groups, with two or three members in each group. They used the cooperative learning model to create concept maps about the topics which would be discussed in the class. In classroom discussions, students used the cooperative learning model to solve mathematics problems. They worked together in small groups with four, five, or six members. To complete the exercises after class, students also used the cooperative learning model. They worked together in small groups with two or three members.

### 2.9 Students’ Reflective Journals

In the context of learning, reflection is a term that relates to cognitive and affective activities in which students explore their thoughts and experiences in order to lead to new understandings and appreciations (Atkins & Murphy, 1993; Baccarini, 2004; Boud, Keogh, & Walker, 1990). According to Moon (1999) and Baccarini (2004) the purposes of doing reflection in learning is to facilitate
learning from experience; through doing reflection students have opportunity to record and reflect their experiences so that they will be able to construct their understandings of the materials. To review something critically, through reflection students have the opportunity to analyse and reflect on what they have learnt thus enabling them to deepen their understanding of the topics. To link theory from observation, through doing reflection students have the opportunity to observe what they have learnt so that they will be able to connect theories that they have met in the learning process.

Students’ reflective journals invariably relate to coursework, such as assignments, course materials, set readings, and tutorials (Moon, 1999). Ballantyne & Packer (1995) have stated that students may be asked to critically reflect on the content of course materials, making connections between concepts presented, and their own observations or experiences.

In this study, students wrote reflective journals about what they had learnt during one week of instruction. As resources for their journals, they used the textbook, lecture notes, group discussions, and other resources that they found to support their learning. In writing the reflective journals, students had the opportunity to look back on what they had learnt.

Writing reflective journals helps students focus and extend their thinking by building mathematics understanding. When students write mathematics terms they have opportunities to manipulate, integrate, and restructure knowledge through using and reflecting on their experiences and prior knowledge (Lim & Pugalee, 2004; Ohnemus, 2010). The use of journal writing in learning encourages students to question themselves when they do not understand rather than be dependent upon their teacher to tell them what they were supposed to know. This involves an internalization of authority, responsibility, and control (Clarke, 1993; Ohnemus, 2010).
2.10 Summary of the Chapter

This chapter has discussed in detail about the literature review which related to the use of the ACE teaching cycle approach in the mathematics teaching and learning process at college. The discussion began by identifying the problems of teaching mathematics at teacher training colleges and alternative solutions to overcome them. The next section explained the ACE teaching cycle as an approach that was used in teaching and learning process in this study. This section described how to implement the ACE teaching cycle in the teaching and learning process of mathematics. The main focus of the use of this approach was to improve students’ learning in mathematics and to improve students’ engagement in the teaching and learning process. In relation to these, this chapter also reviews the research literature about students’ engagement and students’ learning in mathematics. As a strategy for teaching and learning mathematics, the ACE teaching cycle approach does not stand alone. The approach refers to constructivism theory and it is also supported by other learning strategies like concept maps, cooperative learning, and reflective journals. This chapter has also discussed the literature review about these terms.
CHAPTER 3
RESEARCH METHODOLOGY

3.1 Introduction

The purposes of this study was to develop, implement, and evaluate the use of the Activity, Classroom discussion, and Exercise (ACE) teaching cycle in an Elementary Linear Algebra course in particular: (1) to investigate the effects of implementation of the ACE teaching cycle in the Elementary Linear Algebra course on students’ engagement, (2) to investigate the effects of implementation of the ACE teaching cycle in the Elementary Linear Algebra course on students’ learning, and (3) to investigate the possibilities and the limitations of the implementation of the ACE teaching cycle in the Elementary Linear Algebra course.

The main focus in this chapter is to describe and explain the methodology and research methods used by the researcher in answering the research questions. This chapter contains eight main sections, each of them presenting a different aspect of the methodology used in this research. Section 3.2 presents the methodology of the research that discusses action research and mixed methods research. Section 3.3 discusses the methods of data collection. Section 3.4 describes the participants in this study. Section 3.5 describes the elementary linear algebra course. Section 3.6 explains the stages of data collection. Section 3.7 discusses the quality criteria, Section 3.8 the relevant ethical issues, and Section 3.9 presents the summary of the chapter.

3.2 Methodology

This section presents the methodology of this research. The section is divided into two subsections: action research and mixed methods research.
3.2.1 Action Research

In this research, I used an action research methodology. Action research is a systematic investigation conducted by teacher researchers to gather information about how they teach and how well their students learn (Creswell, 2008; Mills, 2007). According to Atweh (2004) through action research teachers have an opportunity to improve their practice and to develop an understanding of their practice that will enable them to develop professionally. Action research has been used by educators for over 40 years as one of the most practical and efficient methods of conducting research (Greenwood & Levin, 1998). The action research solves a practical and local problem, such as a classroom issue faced by an educator (Creswell, 2008). McMillan (1992) stated that the aim of action research was to solve a specific classroom problem or to make a decision at a local site in order to improve teaching and learning practice immediately within one or more classrooms. Through action research, teachers or lecturers have the opportunity to improve their teaching practice by studying problems or issues they face. They reflect on these issues, collect and analyse data, and implement changes based on their findings and experiences (Creswell, 2008).

According to Mills (2007) and Creswell (2008) there are two basic research types of action research, namely: practical action research and participatory action research. The characteristics of practical action research are: studying local practices, involving individual or team-based inquiry, focusing on teacher development and student learning, implementing a plan of action, and leading to the teacher as researcher. On practical action research, educators seek to research a problem in their own teaching practices so that they can increase their students’ learning and their own professional ability. Teachers/lecturers seek to improve their teaching practice and students’ learning through a systematic study of a local problem (Creswell, 2008). Meanwhile, the characteristics of participatory action research are: studying social issues that constrain individual lives, emphasizing equal collaboration, focusing on life-enhancing changes, resulting in the emancipated researcher. Participatory action research is a systematic study that
has a social and community orientation and has focus on change in our society. The aim of participatory action research is to enhance the quality of communities, organizations, and family life (Creswell, 2008).

Based on the two types above, this study used the practical action research design for the following reasons. Action research allowed me as researcher to do research on my teaching practice and in my own classroom. The process of action research provided opportunity for me to plan, implement, and evaluate the ACE teaching cycle as a new approach of teaching and learning in Padang State University. Practical action research accommodated the use of different teaching strategies to support student learning. According to Atweh (2004) this practical type also gives the opportunity for educators to learn about research findings conducted by other researchers and it also may require a more direct engagement and reflection on the research knowledge.

Manen (1990) revealed several basic assumptions underlying the notion of action research. \textit{The democracy assumption}: this assumption is usually found in action research platforms. The relation between researcher and practitioner should be based on a democratic partnership: dominant relations will not support real change. \textit{The external knowledge assumption}: the view of this assumption is that the teacher-researcher implements action research based on their own understanding rather than to become a consumer of traditional theories of education. The importing of external theoretic knowledge is not compatible with the immediate and local needs of practice in action research. \textit{The action/reflection assumption}: there is the belief that reflection has a unique connection with action so that these concepts are naturally integrated. \textit{The change assumption}: this assumption is very essential. The teacher-researcher conducts action research to bring change in their teaching practice. \textit{The teacher-as-researcher assumption}: the educator is at the centre of the action process ensuring that the research itself will improve teaching and learning practice. These assumptions are infrequently questioned, although some are probably ungrounded (Manen, 1990).
According to Creswell (2008) action research is a dynamic and flexible process and there is no fixed pattern on how to proceed it. However, the following eight steps can be used to illustrate the general approach in conducting action research.

Step 1. Decide if action research is the best design to use. Action research might be used to solve a problem, especially a problem in our own professional work or in our community. Action research requires that researcher has enough time to collect and analyse data and to experiment with other actions for solving the problem. As a lecturer-researcher, I see that action research is the correct design to overcome the problems that I face in my teaching practice. This is based on my desire to enhance my professional ability. I had time for a semester to do research so it was possible for me to use action research during the semester. I had sufficient time to collect and analyse the data and implement the strategies.

Step 2. Identify the problems to study. The problems to solve are the most important aspect in action research. The problems may come from our teaching practice or from our community. In this study, the problems that I want to solve were the low engagement of students as well as learning of mathematics. As a mathematics lecturer at Padang State University, I found that these two issues became the major problems of my teaching practice.

Step 3. Identify resources to help address the problem. The researcher in action research needs to find suitable resources to help study the problems. The researcher needs to review the research literature, asks for advice from colleagues, and teams up with knowledgeable people who have also conducted action research. In this study, to direct the research on the right track the researcher referred to several research studies in the literature, discussed with friends, and asked my supervisor for advice.

Step 4. Identify information that we will be needed. The researcher needs to formulate a plan for collecting data; what type of data need to be collected, who can provide the data, how many people will be involved in the study, and so on. In
this study, the information that I needed was about students’ learning and students’ engagement. I obtained the relevant data from 37 students in a class that attended an Elementary Linear Algebra course in the Mathematics Education Study Program in the January-June 2011 semester.

**Step 5. Implement the data collection.** Some of the activities in this step involve keeping an accurate record of the information, organizing it into data files for numeric or thematic analysis, and examining the quality of the information. Data in this study were collected through focus groups, classroom observations, a questionnaire, concept maps, and reflective journals.

**Step 6. Analyse the data.** The result of this step will give the researcher useful information to formulate a plan of action. In this study, there are two kinds of data namely, quantitative data and qualitative data. To analyse the quantitative data I used the Microsoft Excel software to obtain descriptive statistics like mean values and standard deviations; as for the qualitative data I used NVivo software to organise the data.

**Step 7. Develop a plan for action.** This plan may be an alternative strategy to help solve the problem. As a lecturer-researcher, action research gave me the opportunity to prepare a research journal about what had happened in my teaching practice. I became aware of the points at which the weaknesses occurred so I had the opportunity to overcome them for the next session of my teaching practice.

**Step 8. Implement the plan and reflect.** The plan is a potential strategy to solve the problem. The implementation of this plan must be observed to ascertain its impact. The researcher also needs to reflect on what happened as a result of the implementation. In this study, the information that I obtained from several sources would be used to formulate a plan to enhance the next teaching and learning process.

Kemmis and McTaggart (1988) have suggested that action research engages teacher researchers in a four step process which is called the action research
spiral, with its components of planning, acting, observing, reflecting and creating a revised plan. In the planning step, a plan of action is developed to solve a problem which has been identified in order to improve the quality of the teaching and learning practice. In the acting step, the plan is implemented in the teaching and learning activity over a period of time. In the observing step, the effects of the action are observed to ascertain its effectiveness. In the reflecting and creating a revised plan step, the effects of the implementation of action are evaluated to form the basis for the next cycles of research.

In this study, I had planning to improve my teaching practice on Elementary Linear Algebra course at Padang State University by using the ACE teaching cycle approach. I implemented the approach for one semester (January – June 2011). One cycle of action research (planning, acting, observing, reflecting and creating a revised plan) was conducted during each week. *Planning* - as a lecturer-researcher I had a plan to be implemented every week. This plan was related to the teaching and learning strategy that I would be using in the class. *Acting* - I tried to implement the plan that I had created in the classroom. *Observing* - I observed the effects of the use of the plan during that week on the teaching and learning process and students’ learning. *Reflecting and creating a revised plan* - I did a reflection based on my observations during that week. The results of my reflection would be useful for me to revise the plan and to devise new plan to be implemented the following week.

### 3.2.2 Use of Mixed Methods

Before discussing about mixed methods, this section begins with what is meant by quantitative research and qualitative research. According to Creswell (2008) quantitative research is a kind of educational research in which the researcher decides what to study, asks specific, narrow questions, collects measurable data from participants, analyses these data using statistics and conducts the inquiry in an unbiased, objective manner. A quantitative research approach needs more than just the use of numerical data. Before conducting the research, a quantitative
researcher states the hypothesis to be tested and specifies the research procedures that will be used in the study. S/he also takes control over appropriate factors that may interfere with the data collection and identify a sample of participants large enough to provide statistically meaningful data. Many quantitative researchers have little personal interaction with the participants whom they study because they frequently collect data using non-interactive instruments like questionnaires or tests. The quantitative researchers have the view that we live in a relatively stable, uniform, and coherent world that we can measure, understand, and generalize. This view implies that the world is something predictable and can be understood by scientific research (Mills, 2007). By comparison, qualitative research is a kind of educational research in which the researcher relies on the views of participants, asks broad, general questions, collects data consisting largely of words (or text) from participants, describes and analyses the data for themes, and conducts the inquiry in a biased, subjective manner (Creswell, 2008).

According to Mills (2007) qualitative research uses descriptive approaches to understand the data and what the research means from the perspective of the participants in the study. Qualitative methods might include, for instance, conducting face to face interviews, making observations, and audio/video recordings.

A study might incorporate both quantitative and qualitative approaches; the two techniques need not be considered mutually exclusive. Research that combines the collection of quantitative and qualitative data in a single study is called mixed methods research design. Mixed methods research is a term that has come to describe a class of research where the researcher mixes or combines qualitative and quantitative research methods in the same study (Lewis, 2011; Mills, 2007).

This study used a mixed methods approach to collect, describe, and interpret the data. According Creswell (2010) the use of mixed methods in a single study has several advantages. Mixed methods research offers strengths that balance the limitations of both quantitative and qualitative research. The combination of the two approaches builds on the synergy and strength that exist between quantitative
and qualitative research approaches and also to understand a phenomenon more fully than is possible using either method alone (Creswell, 2008; Mathison, 1988; Mills, 2007). Researchers in a mixed methods research approach are able to use all of the data collection available to support studying a research problem rather than being restricted to the types of data collection normally related to qualitative approach or quantitative approach. Mixed methods research helps researchers to solve the research problems that cannot be solved by qualitative or quantitative research alone. Mixed methods provide a bridge between qualitative research and quantitative research. The divisions between qualitative research and quantitative research only serve as a restriction to research approaches and to the opportunities for collaboration (Creswell, 2010).

According to Greene, Caracelli, & Graham (1989) and Lewis (2011) there are four reasons for conducting mixed methods research: (1) Seeking convergence and justification of outcomes from different methods that are studying the same phenomena. For example, several sources of data are used to describe a single case in a case study research. The method is commonly referred to as triangulation. (2) Seeking to elaborate, expand or enhance the outcome from one approach compared with the outcome of another approach. For example, interviews may lead to explain contrary findings in the analysis of questionnaire data. (3) The results from one method are used to inform or develop another method. For example, focus group interviews may be conducted before a questionnaire is developed. In the same research project, direct observations may be used to access small populations while a questionnaire may be used to access larger populations. (4) Using an approach to ascertain a new perception in an area of research enquiry leads to a new view and possible reframing of the research question. For example, interviews may be performed with persons who are known to have differing views so that the researcher can obtain an in-depth understanding of the issues before framing the research question and developing the research design.
Qualitative and quantitative data have been used in this study. The qualitative data were obtained from focus group interviews, classroom observations, students’ reflective journals, and mathematics concept maps. The quantitative data were obtained from the Student Engagement in the Mathematics Classroom (SEMC) questionnaire. The data which were collected from these different approaches presented a coherent picture of how students’ learning and students’ engagement changed as a consequence of the implementation the ACE teaching cycle in the Elementary Linear Algebra course at Padang State University.

3.3 Research Design

In this section I will discuss the instruments that were used in the research, the participants who were involved in the research, and the teaching and learning activities that were implemented.

3.3.1 Instruments

This part explains in depth about focus group interview, classroom observations, reflective journals, and concept maps that had been used to obtain qualitative information. Also, the quantitative information-gathering technique using a questionnaire in this study is presented.

3.3.1.1 Focus Groups

A focus group interview is the process of collecting data through interviews with a group of people, typically four to six persons (Creswell, 2008). The purposes of using focus group interviews in a research are: (1) to get more in-depth information on perceptions, insights, attitudes, experiences, or beliefs, (2) to gather supplementary information in addition to the quantitative data collection methods, and (3) as part of a mixed methods approach (Briefs, 2008).

The use of focus group interviews as a method in research has advantages and disadvantages. The major strength of the use of the focus group interview method is to allow for in-depth analysis and pursuit of details geared to each respondent;
its major limitation is personal in nature that may lead to students saying things to please, rather than be truthful (Anderson, 2002).

According to Briefs (2008) the key success of using focus group interviews in a research is thorough planning. Two important components of the planning are the participants and the guide. The researcher has to decide on the participants from whom s/he wants to obtain information. Each individual focus group should be made up of similar individuals, so the number of focus groups will depend on how many different types of groups from which researcher intends to obtain information. The guide is a series of questions and prompts for the researcher to use. The guide serves as a road map and memory aid for the researcher.

In this study, I obtained information from a focus group. The focus group consisted of six students, three females and three males. They were selected randomly at the end of the course from eight groups in the class. One person represented one group. Actually, eight students were meant to be in the focus group but two of them were absent at the time of the interviews. The focus group interviews were conducted once at the end of the semester for sixty minutes. There were five main questions as a guide in the focus group interviews. The questions are as follows: (1) Please tell me about your views about Mathematics! You may consider difficulties, uses, and enjoyment. (2) What can you tell me about learning/studying mathematics? (3) How is this approach for studying mathematics different from what you have previously experienced? (4) What are some problems/difficulties that you have faced in studying/learning mathematics using this approach? (5) How has this method affected your engagement in studying/learning mathematics?

Students’ responses in this focus group interview contributed to answering the research questions (1) What is the effect of implementing the ACE teaching cycle in the Elementary Linear Algebra course on students’ engagement at Padang State University? (2) What are the possibilities and the limitations of the
In this research, I used a digital recorder to record all conversations. The focus group interview was conducted in the Indonesian language. The transcripts of the interviews were written in the Indonesian language, and then translated into English by the researcher. In the translation process, I was helped by two PhD students at SMEC in Curtin University from Indonesia. They helped to ascertain the accuracy of the translation.

3.3.1.2 Questionnaire

A questionnaire is an instrument that consists of the questions that are asked by the researcher directly (in face to face interaction) or indirectly (using papers) (O'Toole & Beckett, 2010). There are three formats of a questionnaire based on question responses: closed questions, open questions, or both. Closed questions are difficult to construct but easy to analyse whereas open questions are easy to construct but difficult to analysis (Sarantakos, 2005). The major strength of the use of the questionnaire in research is possibly to facilitate quantitative analysis and the use of powerful descriptive and inferential statistics. The major limitation is non-response bias (Anderson, 2002) when students will not respond due to ‘questionnaire fatigue’.

In this study, I used a closed questions questionnaire. According to Sarantakos (2005) closed questions are easy to administer, easily coded and analysed, allow comparisons and quantification, and they are more likely to produce fully completed questionnaires while avoiding irrelevant responses. The questionnaire that I used was a student engagement scale based on the Student Engagement in the Mathematics Classroom (SEMC) questionnaire (Kong et al., 2003). The main purpose of using this instrument in this study was to collect the data which facilitated in answering the research question, “What are the effects of the
implementation of the ACE teaching cycle in the Elementary Linear Algebra course at Padang State University on students’ engagement?”

The SEMC questionnaire comprises three constructs: cognitive, affective and behavioural engagement. The construct of cognitive engagement is closely related to approaches to learning namely, surface strategy, deep strategy, and reliance. Affective engagement implies a sense of belonging and an acceptance of the goals of the learning process. It involves interest, achievement orientation, anxiety and frustration. Behavioural engagement relates to students participation, attentiveness and diligence (Kong et al., 2003).

The SEMC questionnaire was developed in 2003 to measure students’ engagement in the mathematics classroom. Large-scale studies in China established that the instrument of the SEMC questionnaire was valid and reliable (Kong et al., 2003). For the validity, items were constructed based on classroom observations followed by interviews. The developers conducted classroom observations to ensure that the three constructs (cognitive, affective and behavioural engagement) were used to design the instrument items. When developing the items, they also referred to some questionnaires such as the Affective Engagement Questionnaire (Miserandino, 1996), Student Engagement Questionnaire (Marks, 2000), and the Learning Process Questionnaire (Biggs, 1987). For reliability, the developers administered the test to 546 students in Shanghai. The data obtained were analysed to find the reliability index, Cronbach alpha. The result showed that every subscale of the instrument had the Cronbach alpha value above 0.78. This meant that all of the subscales were reliable (Kong et al., 2003).

In the present study, this questionnaire was translated into the Indonesian language to accommodate the language needs of the participants. The researcher translated all items of the questionnaire. After that, the translation was given to two PhD students from Indonesia at SMEC in Curtin University for accuracy of the translation. Their assistance was very helpful to improve the readability of
questionnaire by students. The researcher in this study did not investigate the validity and reliability of the Indonesian version of the questionnaire, because the main intention of using the questionnaire in this study was to triangulate with other data as an indication of engagement.

Through the questionnaire I obtained quantitative data about students’ perceptions of their engagement in mathematics classrooms before and after the use of the ACE teaching cycle. These data enabled me to answer the first research question in this study namely, “What are the effects of implementation of the ACE teaching cycle in the Elementary Linear Algebra course on students’ engagement at Padang State University?

3.3.1.3 Classroom Observation

Classroom observation is the procedure of gathering direct information by observing students in the classroom (Creswell, 2008). The strength of the use of the observation method is that the researcher can record the real students’ activities in the class that are appropriate to a given situation. Its weakness is inability of researcher to record everything that is happening in the class (Mills, 2007).

According to Creswell (2008) to observe the teaching and learning process in the classroom, a researcher needs to adopt a particular role. There are three observational roles that could be used: the role of a participant observer, the role of a nonparticipant observer, and changing observational roles (Creswell, 2008). A participant observer is an observational role adopted by a researcher when s/he takes part in the activities in the setting that s/he observes. A nonparticipant observer is an observer who records notes without becoming involved in the activities of the participants. S/he does not actively participate in the research. A changing observational role is one where an observer adapts her or his role to the situation, from being a nonparticipant observer slowly becoming a participant observer or the reverse.
In this study, I used the role of a participant observer because I was involved actively in the teaching and learning process as well as the researcher. The purpose of this observation was to get information about students’ learning that enabled me to answer the research question, “What are the effects of the use of the ACE teaching cycle on students’ learning in the Elementary Linear Algebra course at Padang State University?” The students’ learning that was observed through this observation was students’ ability in problem solving, communication, and students’ understanding on concepts and procedures. Besides this, the classroom observation was also intended to find out about students’ engagement in the classroom that enabled me to answer the research question, “What are the effects of the implementation of the ACE teaching cycle in the Elementary Linear Algebra course at Padang State University on students’ engagement?”

In this observation, besides making notes about what happened in the class I also used audio digital recorder to record students’ voices in the discussion. The discussions among students in three groups (Group B, Group C, and Group D) were recorded during the semester (12 weeks). These groups were selected randomly from eight groups at the beginning of the semester. Every week, the discussions of only one group were recorded. All digital files of the audio recorder have been saved in the source folder of the Nvivo program at a SMEC computer.

For analysis purposes, I used two records of Group B discussions (discussion on week 2 and week 6). Students’ communication during discussions was transcribed verbatim and then was translated into English. I was helped by two PhD students from Indonesia who are studying at SMEC in Curtin University for the accuracy of the translation. The translation has also been saved in the Nvivo program that was ready for analysis.

3.3.1.4 Concept Maps

Concept maps were first introduced by Novak as a research tool, presenting in a special graphical way the concepts related to a given topic together with their interrelations (Brinkmann, 2005). Although the primary goal was to use concept
mapping in research, it was also found to be a useful tool in the teaching and learning process, helping students to learn how to learn. The method of concept mapping has been developed specifically to tap into a learner cognitive structure and to externalise what the learner already knows (Brinkmann, 2005; J D Novak, 1990).

In this study, students were asked to create concept maps in their small groups (comprising two or three members) as an activity outside the classroom. The concept maps that students created were about materials that would be discussed in the classroom and have not been discussed in the class as yet. The type of concept maps which they created was graph-from-scratch (Ruiz-Primo et al., 2001), where students were required to find concepts and linking phrases through textbook that they used.

The concept maps that were produced by students were also used as a source of data in this study. The information that was obtained from the concept maps was about students’ understanding of mathematics that enabled me to answer the research question, “What are the effects of the use of the ACE teaching cycle on students’ learning in the Elementary Linear Algebra course at Padang State University?” Concept maps can be used to evaluate students’ mathematical knowledge (Bolte, 1997; Ozdemir, 2005).

The focus of students’ learning performance that was observed through the concept maps was to ascertain the increase in students’ preparation of mathematics materials that would be discussed in the classroom. For analysis purposes, I chose one group randomly. The group that was selected was Group D1, the distribution of the groups in this study can be seen in table 3.1 below. During the semester, 11 concept maps were created by Group D1; I chose three concept maps, one each from weeks 2, 5 and 10 for analysis.
Table 3.1: Distribution of Groups for Classroom Discussion, Concept Maps, and Exercise

<table>
<thead>
<tr>
<th>Groups for Classroom Discussion</th>
<th>Groups for Concept Maps and Exercise</th>
<th>Number of Members</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>A2</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>B1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>B2</td>
<td>2</td>
</tr>
<tr>
<td>C</td>
<td>C1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>C2</td>
<td>2</td>
</tr>
<tr>
<td>D</td>
<td>D1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>D2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>D3</td>
<td>2</td>
</tr>
<tr>
<td>E</td>
<td>E1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>E2</td>
<td>2</td>
</tr>
<tr>
<td>F</td>
<td>F1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>F2</td>
<td>2</td>
</tr>
<tr>
<td>G</td>
<td>G1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>G2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>G3</td>
<td>2</td>
</tr>
<tr>
<td>H</td>
<td>H1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>H2</td>
<td>2</td>
</tr>
</tbody>
</table>

3.3.1.5 Students’ Reflective Journals

In the context of learning, reflection is a term that relates to cognitive and affective activities in which students engage to explore their thoughts and
experiences in order to lead to new understandings and appreciations (Boud et al., 1990). Students may be asked to critically reflect on the content of the course materials, make connections between concepts presented, and their own observations or experiences (Ballantyne & Packer, 1995). The reflections will enable them to consider the process of learning, to facilitate learning from experience, to review something critically, to build theory from observation, to engage in personal development, to resolve uncertainty, and to empower them (Baccarini, 2004; Moon, 1999).

According to Schon (1991) there are two types of reflection namely, reflection in action and reflection on action. Reflection in action is a kind of reflection that is done while practising and allows for modification of actions and decisions as necessary. Reflection on action is a reflection that is done after the event. In the teaching and learning process, reflection on action was thought to be more appropriate than reflection in action because students feel more comfortable to reflect upon past actions so that they could focus on reflection only. It is easier to express a learning situation based on reflection on action, as reflection on action causes less pressure and anxiety compared to reflection in action (Baccarini, 2004; Schon, 1991).

In this study, the type of reflection that was used by students was reflection on action. Students were asked to write reflective journals as homework about what they had learnt for one week. To complete this homework, students engaged in open-ended reflection. The instruction that was given to the students was, “Please write about what mathematics knowledge that have you acquired over one week of learning on at least two pages of folio-size paper”. Students’ reflective journals were not only used as a learning activity and as an assessment, but also as a source of data for research.

As a source of data for research, students’ reflective journals contributed to answering the research question, “What are the effects of the use of the ACE teaching cycle on students’ learning in the Elementary Linear Algebra course at
Padang State University?” The students’ learning that was observed through their reflective journals was their understanding on concepts and procedures.

3.3.1.6 Lecturer’s Research Journal

The lecturer’s research journal is a record about his personal and private space that is written honestly about what is happening in the classroom and in the school. It is a safe place where the researcher can talk to herself or himself and experiment with new ways of thinking and feeling (Pine, 2009). The major strength of the use of the journal is helpful in planning future action, generating research questions, developing new insights about teaching, making connections between thought and action, making connections between classroom situations and broader frameworks, assessing the effectiveness of teaching strategies, and determining how well students are learning. The major limitation of the use of the journal is if journaling is not done on a regular basis, then its potential for facilitating teacher/lecturer reflection, action, and growth is lost (Pine, 2009).

In this study, the researcher made notes in his research journal on every meeting or lectures. These notes were made spontaneously about the specific occurrences that happened in the classroom, for example, a student’s objections to the use of the ACE teaching cycle at the beginning of its implementation, classroom atmosphere, students’ presentation, time allocation for each session in the classroom, etc. Soon after class, the researcher typed and saved the record on the computer. These research journals were useful for teaching and learning activities as well as for research activities. For teaching and learning, these reflections were used to improve the teaching and learning practices in the subsequent lectures. For research, these notes were used to answer the research question, “What are the possibilities and the limitations of the implementation of the ACE teaching cycle in the Elementary Linear Algebra course at Padang State University?”
3.3.2 Participants of the Study

In the January-June 2011 semester, there were two classes of the Elementary Linear Algebra course in the Mathematics Education Study Program. I was required to teach one class and the other class was taught by another lecturer. All the 37 students in my class became the participants in this study. They consisted of 28 females and 9 males. All of them were Year 2 students of the Mathematics Education Study Program of Padang State University in the academic year 2010/2011. Their ages ranged from 19 to 22 years. The majority of the participants came from West Sumatera province, the province where the university is located.

3.3.3 Teaching and Learning Procedure

This section contains the following subsections: the Elementary Linear Algebra course, the teaching and learning approach, and assessment.

3.3.3.1 Elementary Linear Algebra Course

Elementary Linear Algebra is a compulsory subject in the Mathematics Education Study Program. This course covers the basic concepts of linear equation systems, determinants, and vector space. Students’ understanding of the concepts in this subject is very important for studying other subjects in subsequent semesters. Some subjects like Abstract Algebra and Applied Mathematics require Elementary Linear Algebra as a prerequisite course.

The competencies to be possessed by students after attending the course are as follows: (1) students are able to perform standard operations and elementary row operations on matrices, (2) students are able to solve any system of linear equations, (3) students are able to find the determinant and inverse of any quadratic matrix, (4) students are able to use the properties of vector space to solve problems in vector space, (5) students are able to use properties of inner
product space and perform orthonormalization, and (6) students are able to use the properties of linear transformation to solve mathematics problems.

This subject has a weightage of 3 SKS (semester credit system). 1 SKS means students have to learn in the classroom for 1 lesson hour (50 minutes) and have to do the assignment for two lesson hours (2x50 minutes) outside the class in a week. The topics included in this subject are: system of linear equations and matrices, determinant, vector space, inner product space, and linear transformation. This subject is allocated a time of 12 weeks in one semester.

Table 3.2 below presents the mathematics topics and the specific aims for each week of lectures. The topics and specific aims for each weekly lesson are presented in the syllabus of the course that was developed by the Mathematics Education Study Program of Padang State University.

Table 3.2: Mathematical Topics and Specific Aims for lessons on each-Week

<table>
<thead>
<tr>
<th>Week</th>
<th>Mathematics Topics</th>
<th>Specific Aims</th>
</tr>
</thead>
</table>
| 2    | System of Linear Equations:  
- Definition of System of Linear Equations  
- Augmented matrix  
- Elementary Row Operation  
- Row Echelon matrix and Row-Reduced Echelon Matrix  
- Gauss-Jordan Elimination  
- Homogenous System of Linear Equations | Students are able to:  
- Explain characteristics of row echelon matrix and row-reduced echelon matrix.  
- Use elementary row operation to determine the solution of System of Linear Algebra  
- Analyse conditions of a system of linear equations that has exactly one, infinite, or no solution. |
| 3    | Matrices and Operations  
- Matrix definition  
- Equality of matrices  
- Matrix addition, multiplication, and scalar multiplication.  
- Properties of the operation  
- Special forms of matrices  
- Transpose Matrices | Students are able to:  
- Explain definition of matrix and properties of special matrix.  
- Check condition whether a matrix operation is defined or not.  
- Perform matrix operations and their properties.  
- Use the properties of transpose matrices. |
| 4    | Elementary matrices  
- Row equivalent  
- Inverse of matrix  
- System of Equation and Invertibility | Students are able to:  
- Recognize elementary matrix and write a matrix as product of elementary matrices.  
- Find inverse of a matrix using |
<table>
<thead>
<tr>
<th>Section</th>
<th>Topics</th>
<th>Students are able to:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-6</td>
<td>- Determinant</td>
<td>- Find determinant using elementary row operation.</td>
</tr>
<tr>
<td></td>
<td>- Determinant and Elementary Row Operation</td>
<td>- Find determinant using cofactor expansion.</td>
</tr>
<tr>
<td></td>
<td>- Cofactor Expansion</td>
<td>- Use properties of determinant to solve problems especially to find inverse and to solve system of linear equations that has exactly one solution.</td>
</tr>
<tr>
<td></td>
<td>- Properties of determinant</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Application of determinant</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>General Vector Spaces</td>
<td>- Check whether or not a set is a vector space.</td>
</tr>
<tr>
<td></td>
<td>- Real vector space</td>
<td>- Use properties of a vector space to solve problems.</td>
</tr>
<tr>
<td></td>
<td>- General vector space</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Properties of vector space</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>- Subspace</td>
<td>- Use definition of subspace to check whether or not a set is a subspace.</td>
</tr>
<tr>
<td></td>
<td>- Linear combination</td>
<td>- Use properties of subspace to solve problems.</td>
</tr>
<tr>
<td></td>
<td>- Spanning set</td>
<td>- Use definition of linear combination and spanning set.</td>
</tr>
<tr>
<td>10</td>
<td>- Linearly independent</td>
<td>- Determine whether or not a set is linearly independent or dependent.</td>
</tr>
<tr>
<td></td>
<td>- Basis and dimension</td>
<td>- Check whether or not a set is a basis of subspace.</td>
</tr>
<tr>
<td></td>
<td>- Coordinates</td>
<td>- Determine the dimension of a vector space</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Explain the relation between spanning set, linearly independent set, and dimension of a vector space.</td>
</tr>
<tr>
<td>11</td>
<td>- Row space and column space of matrix</td>
<td>- Find a basis for row space and column space of a matrix.</td>
</tr>
<tr>
<td></td>
<td>- Rank and nullity</td>
<td>- Determine rank and nullity of a matrix.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Use the properties of rank and nullity to solve problems especially a system of linear equations.</td>
</tr>
<tr>
<td>12</td>
<td>- Inner product space</td>
<td>- Determine whether or not a function</td>
</tr>
<tr>
<td></td>
<td>- Norm, distance, and angle between two vectors</td>
<td></td>
</tr>
</tbody>
</table>
Orthogonality is an inner product. Use properties if inner product to solve problems especially about vector’s norm, distance and position (angle) between two vectors.

| 13 | Orthogonal projection  
- Orthonormal Basis  
- Gram-Schmidt Process | Students are able to:  
- Determine orthogonal projection of a vector to another vector or set of vectors.  
- Make an orthonormal basis. |

| 14 | Linear Transformation  
- Properties of Linear Transformation  
- Matrix of Linear Transformation  
- Kernel and range of Linear Transformation  
- Rank and nullity of Linear Transformation | Students are able to:  
- Check whether or not a mapping is a Linear Transformation.  
- Use properties of Linear Transformation to solve problems.  
- Determine a basis for kernel and range of a Linear Transformation.  
- Determine rank and nullity of a Linear Transformation. |

The table above does not contain Elementary Linear Algebra material in Weeks 1, 9 and 15. The activities in Week 1 were: introduction to the course, explanation of how teaching and learning would be conducted during the semester, information about the research, explanation about how to create concept maps, explanation of how to write reflective journals, and explanation of how to conduct group discussions. Most of the time during this Week 1 was used to explain about mathematics concept maps because this was new for students. They did not have previous experience about the use of concept maps in the learning process. In Week 9 there was the mid-semester test and in Week 15 the final test.

3.3.3.2 Teaching and Learning Procedure

This course used a teaching and learning model or instructional treatments based on the constructivist approach which is called the ACE (Activity, Classroom Discussion, Exercises) teaching cycle (Dubinsky, 2001). The first step in this cycle is ‘activity’. The lecturer gives students the opportunity to do activities that relate to the topic that will be discussed in the next session. This activity encourages students to explore their previous knowledge in order to build new
desired understandings (Dubinsky, 2001). In this study, I used ‘concept mapping activity’ in every weekly lesson. Before students created the concept maps, they were asked to learn the topics individually first so that they had knowledge about these topics. Without having knowledge about the topics students would not be able to create the concept maps. The next step was ‘classroom discussion’ (cooperative learning model) that provides a social context in which the students could work together to solve mathematics problems that were given by the lecturer. Finally, an ‘exercise’ was assigned to be done for homework. In this part, students practised mathematics problem solving and were engaged in reflection to enhance their metacognition. Related to this, students were given activities before class (outside of class), in the class, and after class (outside of class).

Activities before class: students studied the course topics individually through reading sections of the textbook and then they worked in their small groups (2 or 3 members) to produce a mathematics concept map about the topics. These topics were the course materials that would be discussed in the next classroom meeting. The topics were something new for the participants. Through this concept maps activity, the students were expected to have knowledge about the topics. So, they could come to class with confidence and could make their contributions in discussions.

Before the course begun, every student was required to have at least the main textbook of the course, Elementary Linear Algebra written by Howard Anton in Indonesian (Anton, 2004). The lecturer ensured that all students had this textbook; students who did not have the textbook could borrow it from the mathematics department library. This textbook became the main source for them in learning individually and to create the concepts maps.

Students created the concept maps through the discussions in their small groups. They created the maps outside the class. They arranged by themselves when, where, and how long they would work to create the concept maps. The groups comprising two or three students were formed based on the ease of their meeting
outside the class. For this reason, students were asked to form the groups with their close friends or their neighbours where they lived.

*Activities in classroom:* there were four main teaching and learning activities which were designed to be implemented in the classroom. They were as follows: the presentation and discussion of concept maps, lecturer presentation, group discussions, and classroom discussion (classroom discussion was intended to solve the problems that emerged from group discussions). The time allocation that was stipulated by the Mathematics Education Program Study curriculum for the course to do teaching and learning activities was 150 minutes per week.

The presentation and discussion of mathematics concept maps was done at the beginning of the class, when it took about 15 to 20 minutes. Only one group had the opportunity to present the concept map in front of the class. The presenting group was chosen one week before the due date, except for concept map presentation in week 2 when the group was selected during the lesson. After the presentation, the activity continued by a discussion about the concept map.

The next class activity was mathematics content presentation by the lecturer. This presentation took about 40 to 60 minutes. During this time, the lecturer had the opportunity to present the mathematics topics for that week. The materials which were explained by the lecturer were not new for students anymore, because they had interacted with the topics through the concept maps activity, creating and presenting the concept maps. So through this presentation, students had the opportunity to acquire deeper understanding of the topics. Students were also given the opportunity to raise their questions or comments on specific issues about the learning of these topics.

The next activity was group discussion. All students in the class were divided into eight groups. Each group comprised four, five, or six students. In the groups, they discussed the solving of mathematics problems that enabled them to apply the concepts and algorithms that they had studied. These mathematics problems were
intended to explore students’ understanding of the topics. All of the problems were exercises from the Elementary Linear Algebra textbook (Anton, 2004). This session took about 50 to 70 minutes. Below are the examples of the mathematics problems that were used in the group discussions.

*Example 1:* This problem was used as problem 2 in group discussions on week 2.

For which value of \(a\) will the following system have exactly one solution? Infinitely many solutions? No solution?

\[
\begin{align*}
x + 2y - 3z &= 4 \\
3x - y + 5z &= 2 \\
4x + y + (a^2 - 14)z &= a + 2.
\end{align*}
\]

*Example 2:* This problem was used as problem 3 in group discussions on week 4.

Let \(A\) and \(B\) be square matrices of the same size. Is \((AB)^2 = A^2B^2\) a valid matrix identity? Justify your answer.

*Example 3:* This problem was used as problem 4 in group discussions on week 5.

Use the determinant definition to evaluate

\[
\begin{vmatrix}
 0 & 4 & 0 & 0 & 0 \\
 0 & 0 & 0 & 2 & 0 \\
 0 & 0 & 3 & 0 & 0 \\
 0 & 0 & 0 & 0 & 1 \\
 5 & 0 & 0 & 0 & 0
\end{vmatrix}
\]

Each group discussion session was followed by a classroom discussion session. In this stage, they discussed the issues that emerged from the group discussions. For example, if one group couldn’t solve a problem then the group could propose the problem be discussed together in the class. During this discussion, all students in the class had the opportunity to share their ideas and experiences in solving the problem. This session took about 20 to 30 minutes.

*Activities after class:* Students learnt by completing two homework assignments namely, a problem solving exercise and writing a reflective journal. These
assignments were related to the mathematics materials that had been discussed during the week. So, students acquired knowledge and experience through completing these two assignments.

The type of mathematics problems that were solved by students in this session was the same as those that were given for group discussions in class. All the problems were also selected from the exercise sets in the Elementary Linear Algebra textbook (Anton, 2004). To complete the problem solving exercises, students worked in their small groups, the same groups as when they completed the concept maps. The report of their work had to be submitted at the beginning of the class in the following week. By doing these exercises, students were expected to be able to apply their mathematics knowledge to solve the problems enabling them to improve their understanding.

Students worked individually to complete their reflective journals. Their report had also to be submitted at the beginning of the next class. As a result of doing these reflective journals, students were expected to be able to evaluate all topics that they had learnt in the week so that they could be aware of which parts that they understood well and which parts were difficult to understand.

3.3.3.3 Assessment

There were three assessment items in the Elementary Linear Algebra course: tasks/homework, mid-semester test, and final test. The tests were intended to assess students’ ability in the Elementary Linear Algebra course. The test results were used to satisfy college requirement. The results of these tests were not used in this study because this study did not have control group and absolute achievement on test is not meaningful without a comparison. Table 3.3 summarises the list of assessments, allocated marks, and the purpose of each assessment.
Table 3.3: Assessments of Elementary Linear Algebra Course

<table>
<thead>
<tr>
<th>Assessment Producer</th>
<th>Allocated Marks (%)</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tasks/Homework:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concept Maps</td>
<td>10%</td>
<td>Encourage serious participation</td>
</tr>
<tr>
<td>Group Discussions</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>Reflective Journal</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>Exercise</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>Mid-semester test</td>
<td>30%</td>
<td>Assessing achievement in the middle of the semester</td>
</tr>
<tr>
<td>Final Exam</td>
<td>30%</td>
<td>Assessing achievement at the end of the semester</td>
</tr>
</tbody>
</table>

3.4 Phases of Data Collection

In action research, data collection is an important stage to evaluate the whole process of the teaching and learning. In this study, the data from several sources were used to determine the effects of the use of the ACE teaching cycle on students’ engagement and students’ learning. These data became a basis for my reflection to improve my teaching practice.

There were three phases in the data collection. An overview of these phases in relation to the data collection and the weekly lecture timetable is presented in table 3.4. This illustrates the specific data that were collected each week. While the semester was only 12 weeks long for presenting the materials, data was collected over a 16-week time frame (see Table 3.4).

The initial phase of data collection related to investigating the students’ engagement in the mathematics classroom before the implementation of the ACE teaching cycle in Elementary Linear Algebra course at Padang State University. The Student Engagement in Mathematics Classroom (SEMC) questionnaire was administered to all participants as pre-test in Week 1 to ascertain their level of engagement in mathematics before they learnt using the ACE teaching cycle.

The second phase related to implementing the ACE teaching cycle as a teaching strategy. This phase coincided with the formal instruction during Weeks 2 to 14,
and was conducted from March to June 2011. Data collection activities during this phase involved: analysing concept maps and students’ reflective journals, observations of classroom situations using audio recordings, and the writing of a reflective journal by the researcher about the use of the ACE teaching cycle in the classroom. The information gained from this wide range of data was used to ascertain the levels of students’ engagement and students’ learning in mathematics.

One cycle of action research (planning, acting, observing, reflecting and creating a revised plan) was conducted during each week of this second phase. Planning - as a lecturer-researcher I had a plan to be implemented every week. This plan was related to the teaching and learning strategy that I would be using in the class. Acting - I tried to implement the plan that I had created in the classroom. Observing - I observed the effects of the use of the plan during that week on the teaching and learning process and students’ learning. Reflecting and creating a revised plan - I did a reflection based on my observations during that week. The results of my reflection would be useful for me to revise the plan and to devise new plan to be implemented the following week.

The third phase of data collection related to students’ responses after the implementation of the ACE teaching cycle. In this phase, data were collected using the Student Engagement in Mathematics Classroom (SEMC) questionnaire as post-test and focus group interviews.

Table 3.4: Summary of Data Collection

<table>
<thead>
<tr>
<th>Phase</th>
<th>Week</th>
<th>Date</th>
<th>Method of Data Collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>02/03/2011</td>
<td>SEMC Questionnaire (Pre-test)</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>09/03/2011</td>
<td>Concept maps, classroom observations (audio recordings),</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>and lecturer’s research journal</td>
</tr>
<tr>
<td>3</td>
<td>16/03/2011</td>
<td>Concept maps, classroom observations (audio recordings),</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td></td>
<td>students’ reflective journals, and lecturer’s reflective</td>
</tr>
<tr>
<td></td>
<td>16/03/2011</td>
<td>journal</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>23/03/2011</td>
<td>Concept maps, classroom observations (audio recordings),</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>students’ reflective journals, and lecturer’s research</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>journal</td>
</tr>
</tbody>
</table>
5 30/03/2011 Concept maps, classroom observations (audio recordings), students’ reflective journals, and lecturer’s research journal
6 06/04/2011 Concept maps, classroom observations (audio recordings), students’ reflective journals, and lecturer’s research journal
7 13/04/2011 Concept maps, classroom observations (audio recordings), students’ reflective journals, and lecturer’s reflective journal
8 20/04/2011 Concept maps, classroom observations (audio recordings), students’ reflective journals, and lecturer’s research journal
9 27/04/2011 Mid-semester test
10 04/05/2011 Concept maps, classroom observations (audio recordings), students’ reflective journals, and lecturer’s research journal
11 11/05/2011 Concept maps, classroom observations (audio recordings), students’ reflective journals, and lecturer’s research journal
12 18/05/2011 Concept maps, classroom observations (audio recordings), students’ reflective journals, and lecturer’s research journal
13 25/05/2011 Concept maps, classroom observations (audio recordings), students’ reflective journals, and lecturer’s research journal
14 01/06/2011 Concept maps, classroom observations (audio recordings), students’ reflective journals, and lecturer’s research journal
3 15 08/06/2011 Final exam, SEMC Questionnaire (Post-test)
16 15/06/2011 Focus group interviews

3.5 Data Analysis

The results of the data analysis enabled me to answer the research questions and to draw conclusions regarding the use of the approach. In this subchapter, the procedures of data analysis will be discussed. The first section, 3.5.1, discusses how the quantitative data were analysed. Then, section 3.5.2 discusses the analyses of the qualitative data.
3.5.1 Analysis of Quantitative Data

In this study, the quantitative data were obtained from the Students’ Engagement in Mathematics Classroom (SEMC) questionnaire. This questionnaire was administered to participants on two occasions, before (as pre-test) and after (as post-test) the implementation of the ACE teaching cycle in the Elementary Linear Algebra course. Table 3.5 below presents the scales, subscales, and number of items of the questionnaire.

Table 3.5: Scales, Subscales, and Number of Items of SEMC Questionnaire

<table>
<thead>
<tr>
<th>No</th>
<th>Scale</th>
<th>Subscale</th>
<th>Number of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cognitive Engagement</td>
<td>Surface Strategy</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Deep Strategy</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reliance</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>Affective Engagement</td>
<td>Interest</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Achievement Orientation</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anxiety</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Frustration</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>Behavioural Engagement</td>
<td>Attentiveness</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Diligence</td>
<td>6</td>
</tr>
</tbody>
</table>

All items in the instrument requested for responses based on a 5-point Likert scale (1 = almost never, 2 = seldom, 3 = sometime, 4 = often, 5 = almost always). All the 37 participants provided their response to both pre-test and post-test. To organize the data, researcher used Microsoft Excel software. All of the students’ responses were entered into a MS Excel data file.

The descriptive statistics facility in the Microsoft Excel software was used to obtain information about the mean and standard deviation of all items on both tests. The mean of each item on the pre-test and post-test were compared to ascertain changes in students’ answers on every item. The statistical test was not used in this study because the size of the sample was small (37 students); the data would be statistically meaningful when the participant numbers are large enough.
(Mills, 2007). However, the data were still useful for triangulation with other data even though the sample was small.

3.5.2 Analysis of Qualitative Data

In this study, qualitative data were obtained from focus groups, classroom observations, students’ mathematics concept maps, students’ reflective journals, and the lecturer’s research journal. The analysis of qualitative data in this study was performed based on the method proposed by Creswell (2008): prepare and organize data for analysis, explore the general sense of the data, and the process of coding and representing themes. These steps will be discussed in this section.

Preparing and organizing data for analysis: The researcher arranged all the data that had been collected during the study so that the data could be accessed easily and quickly for analysis. The audio recordings from focus group interviews and classroom observations were transcribed, typed in a Microsoft Word document, and saved in specific folders. The handwritten concept maps that were created by students were scanned to become digital files and could be saved in a specific folder in the computer. Students’ handwritten reflective journals were also scanned to produce digital files and saved in a specific folder in the computer. All files that had been collected were labelled and transferred in digital form so that researcher could conveniently access them.

Exploring the general sense of the data: after organising all the data, the researcher studied it to get a general sense of the data. This could be done by reading the data and listening to the audio-recordings several times. Exploring all the data would give the researcher the opportunity to make notes, think about the organisation of the data, identify key points, focus on certain issues, and consider whether or not more data were required (Creswell, 2008).

The process for coding and representing themes: Coding is the process of segmenting and labelling texts or images to form descriptions and broad themes in the data so that the data are more manageable (Creswell, 2008). The researcher
used NVivo 9 software to analyse the collected data. This software was designed for researchers to make sense of complex data. NVivo has a complete toolkit to organize, analyse, and store different types of qualitative data (Creswell, 2008). In this study, all data were saved in a different file format. Focus group interviews, observations, and the lecturer’s research journal data were saved in word processing files (doc format), concept maps and students’ reflective journals were saved in an adobe reader file (pdf format), and audio recordings of focus group interviews and classroom observations were saved in mp3 format. NVivo allowed the researcher to organize the huge amount of data in a systematic way. The NVivo software uses the term ‘nodes’ for themes or categories. The researcher saved all transcripts and file documents directly into the internal source of NVivo package, and then started the coding process. The process of coding is an important part in qualitative data analysing (Strauss, 1987). Through the process of coding, the data could be grouped into several relevant categories or themes so that the data became manageable. Parts that had been coded were reread to look for consistencies and to clarify themes. Comments were grouped into pre-existing categories or nodes that enabled the researcher to answer the research questions and write the research report.

In this study, themes or nodes were created based on theoretical construct that did not emerge from the data. The researcher used the following nodes for students’ engagement. These nodes related to cognitive engagement were Surface strategy, deep strategy, and reliance. These nodes related to affective engagement were interest, achievement orientation, anxiety, and frustration. These nodes relate to behavioural engagement were attentiveness and diligence. The nodes for students’ learning were students’ understanding of concepts and procedures, students’ ability in problem solving, and students’ ability in communication.

Table 3.6 below presents the summary of research method, data collection strategy, instruments used, and data analysis strategy for each of the research aims.
Table 3.6: Summary of Research Methods with Data Collection Strategies

<table>
<thead>
<tr>
<th>Research Aims</th>
<th>Method</th>
<th>Data Collection Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>To investigate the effect of implementation of the ACE teaching cycle in the Elementary Linear Algebra course on students’ engagement.</td>
<td>Interviews, Observations, Questionnaire</td>
<td>Focus Group Interviews, Classroom Observations, Closed Questionnaire</td>
</tr>
<tr>
<td>To investigate the effect of implementation of the ACE teaching cycle in the Elementary Linear Algebra course on students’ learning.</td>
<td>Observations, Students’ Reflective Journals, Concept Maps</td>
<td>Classroom Observations, Weekly Reflections, Group Concept Maps</td>
</tr>
<tr>
<td>To investigate the possibilities and the limitations of the implementation of the ACE teaching cycle in the Elementary Linear Algebra course.</td>
<td>Lecturer’s Research Journal</td>
<td>Weekly Reflections</td>
</tr>
</tbody>
</table>

3.6 The Quality Criteria of the Data

In this research, the data were mainly qualitative data. Four of the five groups of data were qualitative namely, data from focus group interviews, data from concept maps, data from students’ reflective journals, and data from lecturer’s research journal. According to Denzin and Lincoln (1998) to assess the trustworthiness of the qualitative data the researcher could use the following quality criteria: credibility, transferability, dependability, and confirmability. The aim of using these criteria is to satisfy questions of rigour in this study.
3.6.1 Credibility

A research will be credible when the findings accurately describe the phenomena being researched (Cohen, Manion, & Morrison, 2000). There are six basic strategies to ensure credibility namely, triangulation, member checking, member debriefing, prolonged engagement and persistent observation, and negative case analysis (Guba & Lincoln, 1989).

According to Olsen (2004) triangulation in social science is defined as the mixing of methods or data so that various perspectives or viewpoints cast light upon a study. Triangulation is an important aspect to improve research credibility. This study employed triangulation through the use multiple data collection processes; data were collected through interviews, questionnaire, students’ reflective journals, lecturer’s research journal, concept maps, and classroom observations. Triangulation is used to attain coverage of various aspects of a phenomenon to get a deeper understanding (Jick, 1983). The rational for this strategy is that the weaknesses of one method are often the strengths of another so that by combining the methods the researchers can attain the best of each while overcoming their unique shortcomings (Mathison, 1988).

Member checking is an opportunity for participants to check, verify, or approve particular parts of the interpretation of the data they had provided (Carlson, 2010; Doyle, 2007). Member checking was another strategy that has been used in this study to enhance credibility. Member checking was applied to the data of focus group interviews; the Indonesian version of interview transcript was sent to all interviewees using their emails. They were asked to check if the content expressed what they wanted to say and gave them the opportunity to change any part of the transcript content. All of the participants agreed to the contents of the transcripts.

Prolonged engagement is the investment of sufficient time in the field (study) to learn or understand the culture, social setting, or phenomenon of interest (Guba & Lincoln, 1989). Meanwhile persistent observation is intended to identify the
problems or issues being pursued and focusing on them in detail provides depth
(Guba & Lincoln, 1989). The study took place at the Mathematic Department of
Padang State University where I have been a mathematics lecturer since 1993. In
terms of prolonged engagement and persistent observation, this study took place
over one semester (January-June 2011). During the semester, I was directly
involved in the research as a lecturer researcher. I am familiar with the
environment in which data collection was done because I have been a lecturer
there for more than 19 years. So, I had enough time to conduct the research and
had the opportunity to be fully involved.

Regarding negative case analysis, I was able to refine initial assumptions when
contrary finding emerged. Guba & Lincoln (1989) stated that negative case
analysis is a process of revising working assumptions in the light of hindsight,
with an eye toward developing and refining a given assumption until it accounted
for all cases.

3.6.2 Transferability

Transferability is concerned with the extent to which the findings of the study can
be applied to similar situations (Guba & Lincoln, 1989). Transferability requires
that sufficient descriptive information is made available. In this study, strategies
for improving transferability included thorough description of the setting, the
participants, the Elementary Linear Algebra course, and the context of the study.

3.6.3 Dependability

Dependability is concerned with the stability of the data over time or the extent to
which the findings may be replicated (Guba & Lincoln, 1989). The dependability
can be seen through triangulating data, and providing an audit trail (Merriam,
1998). The use of triangulation was presented in the credibility subsection above.
Audit trail is a process which is established, traceable and documentable so that
the analysis of the collected data can be confirmed (Guba & Lincoln, 1989).
Related to this term, all collected data in this study were organized, documented, and analysed to ensure that the research findings emerged in a systematic way.

### 3.6.4 Confirmability

Confirmability is a concept that is concerned with data interpretation and the outcome of inquiries that are rooted in context and a person apart from the evaluator (Guba & Lincoln, 1989). This research has established the findings from the data, and demonstrates that the findings are not simply part of the researcher’s imagination. In this study, confirmability was done by involving participants in checking, verifying, and approving the focus group transcripts. The transcripts of audio recordings of focus group interviews were sent to the participants soon after the researcher had completed the transcribing.

### 3.7 Ethical Issues

This study was given approval by the Human Research Ethics Committee of Curtin University on 18 August 2010 (approval number SMEC-49-10). The ethical issues that were addressed in this study are as follows: informed consent, consideration, anonymity and confidentiality, and acknowledgement.

#### 3.7.1 Informed Consent

At the beginning of the semester all participants were provided with information about the nature and purpose of the research, the methods, as well as any risks and benefits to the participants. It was made clear to all participants that their involvement in this study was voluntary and that they were free to withdraw from the research at any time without prejudice. All data from students who had resigned from the study would not be used for the research. They could, however, still be actively involved in teaching and learning process. All participants were provided with an information sheet and consent form containing this information.
3.7.2 Consideration

During data collection, the participants had minimum disruption to their normal teaching and learning activities. They answered the questionnaire before and after the teaching and learning program. The focus group interviews were conducted after all lectures had been completed. Teaching and learning procedures on the ACE teaching cycle approach were also expected to not disrupt their normal study time because the allocation time had been considered in accordance with what was permitted by curriculum.

3.7.3 Anonymity and Confidentiality

All students who were involved in the research were guaranteed anonymity and confidentiality. To ensure anonymity, only class results were used for the data from the questionnaire. Further, every concept map and students’ reflective journal were assigned a code in place of students’ names. Access to the data gathered was limited to the researcher and his thesis supervisor.

3.7.4 Acknowledgement

All students who were involved in the study were acknowledged for their contribution and cooperation at the end of the Elementary Linear Algebra course. All participants were acknowledged in the acknowledgement section of this thesis report.

3.8 Summary of Chapter

This chapter has discussed the methodologies and described about how the study was conducted from the beginning until the end of the research. This study adopted the action research methodology and used mixed methods to collect, describe, and interpret the data. A variety of data collection procedures was used, including a questionnaire, focus group interviews, concept maps, students’ reflective journals, classroom observations, and the lecturer’s research journal. The different ways of data analysis and interpretation were also discussed. The
chapter also contained the quality criteria to enhance research trustworthiness. Finally, the chapter emphasised the ethical issues addressed in this study.

Table 3.7: Aspect and Approaches of the Research Process

<table>
<thead>
<tr>
<th>Aspect of the Research Process</th>
<th>Approach Taken in this Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methodology</td>
<td>Action Research</td>
</tr>
<tr>
<td>Data Collection</td>
<td>Reflective Journals</td>
</tr>
<tr>
<td></td>
<td>Closed Questionnaire (SEMC)</td>
</tr>
<tr>
<td></td>
<td>Focus Group Interviews</td>
</tr>
<tr>
<td></td>
<td>Audio Recordings</td>
</tr>
<tr>
<td></td>
<td>Concept Maps</td>
</tr>
<tr>
<td></td>
<td>Students’ Journal Writing</td>
</tr>
<tr>
<td></td>
<td>Lecturer’s Research Journal</td>
</tr>
<tr>
<td>Data Analysis/Interpretation</td>
<td>NVivo Analysis</td>
</tr>
<tr>
<td></td>
<td>Descriptive Statistics</td>
</tr>
<tr>
<td>Trustworthiness</td>
<td>Credibility</td>
</tr>
<tr>
<td></td>
<td>Transferability</td>
</tr>
<tr>
<td></td>
<td>Dependability</td>
</tr>
<tr>
<td></td>
<td>Conformability</td>
</tr>
<tr>
<td>Ethical Issues</td>
<td>Informed Consent</td>
</tr>
<tr>
<td></td>
<td>Consideration</td>
</tr>
<tr>
<td></td>
<td>Anonymity and Confidentiality</td>
</tr>
<tr>
<td></td>
<td>Acknowledgment</td>
</tr>
</tbody>
</table>
CHAPTER 4
FINDING AND DISCUSSION

4.1 Overview of Chapter 4

The purpose of this chapter is to discuss the findings from the qualitative and quantitative data. The chapter includes the qualitative data that emerged from focus group interviews, students’ reflective journals, mathematics concept maps, and classroom observations. This chapter also contains the data analysis from the quantitative data. The instrument used for collecting quantitative data in this study was the Student Engagement in the Mathematics Classroom (SEMC) questionnaire.

This chapter consists of four sections. Section 4.1 contains an overview of chapter 4. The three other sections are the main sections of the chapter. The structure of the chapter is based on the research questions in this study.

Section 4.2 presents the effects of the use of the ACE teaching cycle on students’ engagement. This section contains analysis results of qualitative and quantitative data about students’ engagement in the mathematics classroom. This section will provide a response to the research question, “What are the effects of the implementation of the ACE teaching cycle in the Elementary Linear Algebra course at Padang State University on students’ engagement?”

Section 4.3 discusses the effects of the use of the ACE teaching cycle on students’ achievement. This section contains analysis results of qualitative data from classroom observations, concept maps, and students’ reflective journals. This section will provide a response to the research question, “What are the effects of the implementation of the ACE teaching cycle in the Elementary Linear Algebra course at Padang State University on students’ learning?”
Section 4.4 discusses the possibilities and limitations of the use of the ACE teaching cycle on the Elementary Linear Algebra course. This section contains analysis results of qualitative data from researcher’s research journal. This section will provide a response to the research question, “What are the possibilities and the limitations of the implementation of ACE teaching cycle in Elementary Linear Algebra course at Padang State University?

4.2 The effects of the Use of the ACE Teaching Cycle on Students’ Engagement

Students’ engagement is a psychological investment in and effort directed toward learning, understanding, or mastering the knowledge, skills, or crafts that academic work is intended to promote (Newmann & Lamborn, 1992). D’mello (2008) added that engagement involves student’s willingness, need, desire and compulsion to participate in, and be successful in, the learning process. It is an important issue in teaching because it affects how much students learn on a daily basis. The engagement depends greatly on students’ interest and the teacher’s ability to create an environment that invites students to learn (D’mello, 2008; Tomlinson, 2002). In this study, the degree of student engagement in the classroom was evidenced by three domains namely, cognitive engagement, affective engagement, and behavioural engagement (Caulfield, 2010; Chapman, 2003). The data sources for these domains were a questionnaire, focus group interviews, and classroom observations.

According to Rotgans and Schmidt (2011) cognitive engagement is a psychological condition where students do a lot of effort to truly understand a topic and in which students persist with studying over a long period of time. The cognitive engagement is closely related to academic involvement or approaches to learning. The three approaches to learning namely, surface strategy (closely associated with lower levels of learning outcomes – memorisation, practising, handling tests), deep strategy (closely related to higher levels of learning outcomes – understanding the question, summarising what is learnt, connecting
knowledge with the old ways of learning), and reliance (Biggs, 1978; Kong et al., 2003).

Students’ affective engagement is defined by students feelings, attitudes, perceptions, and reactions to the learning environment, for example, high level of interest, enjoyment, or positive attitude towards learning (Archambault, Janosz, Morizot, & Pagani, 2009; Chapman, 2003). According to Miserandino (1996) and Kong, et al. (2003) students’ affective engagement can be seen through four dimensions namely, interest, achievement orientation, anxiety, and frustration.

According to Archambault et al. (2009) behavioural engagement is a psychological experience that concerns students’ active involvement in classroom activities. Behavioural engagement is closely related to student’s participation in the classroom. Active participation in the classroom is demonstrated by: taking initiative in the group and classroom, becoming involved in the classroom activities, asking questions, regularly attending class, and comprehensively completing assignments (Chapman, 2003; Skinner & Belmont, 1993). According to Kong et al. (2003) students’ behavioural engagement in learning could be seen through two aspects, namely; attentiveness and diligence.

### 4.2.1 Students’ Cognitive Engagement

This section discusses analysis of data on three aspects of students’ cognitive engagement: surface strategy, deep strategy, and reliance. Focus of the analysis is to evaluate the effect of the use of the ACE teaching cycle on the three aspects of students’ cognitive engagement. The results of this analysis came from data related to focus group interviews and the closed questionnaire.

#### 4.2.1.1 Surface Strategy Aspect of Cognitive Engagement

As a mathematics lecturer, I always found students used surface strategy (the strategy that relates to lower levels of learning outcomes like memorisation) in their learning process. By implementing the ACE teaching cycle in my teaching
practice in the Elementary Linear Algebra course, I hope that the extent of the use of surface strategy by the students decline and the extent of the use of the deep strategy increases.

In the learning process using the ACE teaching cycle that was implemented in the Elementary Linear Algebra course, I also found that students still used surface strategy in their learning process like memorizing the formulas, definitions, theorems, and the proofs of theorems. They used this strategy in order to stay connected with the topics of the course because the contents of the course contained definitions, formulas, and theorems.

In classroom observations of discussions of Group C in Week 4, Diah said, “A is a matrix 2x2, so to find $A^{-1}$ we can use the formula”. The use of the formula is one alternative to find the solution to the problem. Here, Diah tended to use the formula that was available to solve the problem. The strategy that she used could be categorized as a surface strategy in cognitive engagement because she just needed to memorize the formula and apply it to the problem.

The use of surface strategy in learning was also revealed by Vera in one of the focus groups. Vera said, “When I had difficulty to understand a definition or a theorem, then I would do memorize the definition or the theorem.” Definitions and theorems are two important terms in mathematics. Sometime, students found difficulty to understand them well in a short time. This fact encouraged some students to memorize them in their effort to keep up with the lesson, like what was revealed by Vera. The strategy that has been used by Vera could also be categorized as a surface strategy of cognitive engagement.

Another fact that was revealed by students related to the use surface strategy in learning was revealed by Yanti in one of the focus groups. “I would do memorize when I found terms which difficult for me to understand. For example, I sometime found hard to understand some steps of a theorem proof, so I memorize the steps.”

*Note: All names of the research respondent in this thesis are pseudonyms*
The understanding of proving of a theorem is very important for students to know how a theorem is build up, but sometime students get difficulty to understand the proof of the theorem as experienced by Yanti. To keep connected with the theorem some students did memorize the proof of the theorem like what Yanti did because the theorem was part of the content of the course that should she learnt. This was a surface strategy of cognitive engagement.

However, although surface strategy is related to lower levels of learning outcomes, this strategy still showed students’ engagement in learning through memorizing various facts and rules in mathematics (Kong et al., 2003). Through using this strategy, they tried to understand the topics being studied despite the fact that such material was difficult for them to understand. By memorizing these facts it enabled them to be still engaged in the lessons.

The information about students’ surface strategy of cognitive engagement was also obtained from the closed questionnaire. The questionnaire was administered to the participants on two occasions, before and after the use of the ACE teaching cycle approach. The main intention of the qualitative data from this questionnaire was to evaluate the effect of the use of the approach. Table 4.1 and Table 4.2 below present the results of the analysis of students’ responses to the questionnaire about the surface strategy aspect of cognitive engagement in the pre-test and post-test.

Table 4.1: Descriptive Statistics for the Surface Strategy Subscale of the SEMC in the Pre-Test and Post-Test (n=37)

<table>
<thead>
<tr>
<th>No. of items</th>
<th>Pre-test</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Standard deviation</td>
<td>Mean Standard deviation</td>
</tr>
<tr>
<td>7</td>
<td>2.98 1.02</td>
<td>2.92 0.89</td>
</tr>
</tbody>
</table>

As shown in table 4.1 above the mean value of surface strategy subscale in the post-test (2.92) was slightly lower than that in the pre-test (2.98). This result was consistent with what I had expected, i.e., there was a decline in students’ use of the surface strategy in the mathematics learning process. The use of the ACE
teaching cycle had encouraged students to be involved in a series of learning activities in a mathematics topic. This gave students more opportunity to learn more widely and deeply so that it resulted in a decrease in the use of surface strategy which was previously used by students. More details about this result can be seen in Table 4.2 below.

Table 4.2: Mean of the Students’ Answers to each Item of the Surface Strategy Subscale of the SEMC in the Pre-test and Post-test.

<table>
<thead>
<tr>
<th>No</th>
<th>Items</th>
<th>Mean Pre-test</th>
<th>Mean Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I find memorising formula is the best way to learn mathematics.</td>
<td>3.22</td>
<td>2.78</td>
</tr>
<tr>
<td>2</td>
<td>In learning mathematics, I prefer memorising all the necessary formulas rather than understanding the principles behind them.</td>
<td>2.65</td>
<td>2.70</td>
</tr>
<tr>
<td>3</td>
<td>I think memorising the fact and detail of a topic is better than understanding it holistically.</td>
<td>2.76</td>
<td>2.65</td>
</tr>
<tr>
<td>4</td>
<td>In mathematics learning, it is very useful to memorise the methods for solving problem.</td>
<td>2.86</td>
<td>3.22</td>
</tr>
<tr>
<td>5</td>
<td>In mathematics learning, I prefer memorising different methods of solution; this is very effective way of learning.</td>
<td>3.22</td>
<td>3.16</td>
</tr>
<tr>
<td>6</td>
<td>I think the best way of learning mathematics is to memorise facts by repeatedly working on mathematics problems.</td>
<td>4.14</td>
<td>3.73</td>
</tr>
<tr>
<td>7</td>
<td>I think memorising mathematics is more effective then understanding it.</td>
<td>2.03</td>
<td>2.24</td>
</tr>
</tbody>
</table>

In the table above, there is a decreasing mean value for several items while the mean value of others increased. The highest decline occurred for item 1, “I find memorising formula is the best way to learn mathematics.” The highest increase could be seen in item 4, “In mathematics learning, it is very useful to memorise the methods for solving problem.” This fact indicated the change in how students used the memorizing strategy in learning. Before the use of the ACE teaching cycle, students tended to memorize formulas, while as a result of learning using the ACE teaching cycle students tended to memorize the method for solving problems. In terms of surface strategy, memorizing the method is more complex
than memorizing the formula. This showed that students engaged more in learning when they memorized the method of solving a mathematics problem compared to when they memorized formulas to solve a problem.

4.2.1.2 Deep Strategy Aspect of Cognitive Engagement

The purpose of analysing data in this section is to evaluate the effect of the implementation of the ACE teaching cycle in the Elementary Linear Algebra course on the deep strategy aspect of students’ cognitive engagement. Deep strategy is closely related to higher levels of learning outcomes – understanding the question, summarising what is learnt, applying knowledge, connecting knowledge with the old ways of learning, etc. As a lecturer and researcher in this study, I hoped that the use of the ACE teaching cycle will have positive impact on the deep strategy aspect of cognitive engagement. The data for this analysis came from focus group interviews, classroom observations, and the closed questionnaire.

Some of the students’ responses that were identified from the focus group interviews that related to the deep strategy aspect as consequence of the use of the ACE teaching cycle in the Elementary Linear Algebra course are discussed below.

Zola said that,

Honestly, at the beginning I found difficulty to make concept maps and reflective journals because they were something new for me. To produce a concept map I had to study hard, I read the material several times until I really understood the concept. Through making the reflective journal I began to better understand the material that I had learnt. I often wrote a reflective journal first before I did the exercises. So, I feel that the learning process with this strategy is very effective.

The use of the ACE teaching cycle in the Elementary Linear Algebra course has produced a positive impact on how Zola learnt the topics, so that he could get in-
depth understanding of the materials. This is possible because he learnt the same topic through several learning activities. He studied hard so that he was able to apply his knowledge to produce concept maps, learnt from the lecturer’s explanations, discussed in the group, wrote reflective journals, and completed exercises. This series of learning activities improved his understanding about the topic. What has been shown by Zola could be categorized as a deep strategy of cognitive engagement.

Febi revealed in the focus group about the use of the ACE teaching cycle:

With this method (ACE teaching cycle), I have to learn first before coming to class. Through this method, before we made a concept map we had to first learn by ourselves and then discuss with friends. If we didn’t understand a concept we can’t produce a concept map.

Febi revealed that this method had accommodated her to learn before class. She tried to understand the material well. She realized that understanding the topics well would facilitate her to be able to create concept maps and to discuss in the class. The discussion activity gave them chance to share knowledge with each other.

Further, Febi also revealed that,

Through discussing in the class we shared information and knowledge. I got the explanation not only from the lecture but also from friends. Through journal writing I could review and summarize the topics and realized which parts I have understood and which parts were difficult. My understanding about the materials became deeper through doing all assignments.

The implementation of the ACE teaching cycle had helped Febi to get better understanding of the materials. She benefited from group discussions, writing reflective journals, and completing all assignments. Through learning by herself
she knew which parts she was able to understand and which parts were hard to understand. As a result, she knew what contribution she could make and what kind of help that she expected to receive from other friends in discussions. Group discussions enabled her to share and change ideas, while writing the journal enabled her to review all topics. What has been revealed by Febi reflected that she used deep strategy of cognitive engagement in learning.

Still on focus groups, Budi also revealed his response related to deep strategy of cognitive engagement:

Before class, I learnt the materials and together with my partner we applied what we have learnt to create the concept map. In the classroom, we discussed the materials. This approach encourages me to study hard. In the conventional classroom, there is no concept map, and there is no reflective journal. There are only exercises to be done. I had allocated more time to learn with this approach.

The use of the ACE teaching cycle approach has facilitated Budi to learn by himself and apply his knowledge to complete the concept maps task. The approach has also encouraged him to study hard and he allocated more time to learn. Budi has also shown that he used the deep strategy of cognitive engagement in learning.

What have been revealed by Zola, Febi, and Budi indicated that they had used deep strategy in their learning process. Through the use of the ACE teaching cycle in the Elementary Linear Algebra course they had opportunities for summarising what was learnt, applying knowledge, connecting knowledge, and using more time in learning. The use of this strategy enabled them to acquire deep understanding of the topics, because this strategy encouraged them to learn intensively.

The qualitative data that related to the deep strategy aspect of cognitive engagement could also be seen through classroom observations. In the Group C
discussion during Week 4, Desi revealed an alternative way to prove that the identity \((AB)^2 = A^2B^2\) is not valid for any square matrices. Desi said, “I think, we can also prove it using a counter example, we can take two particular 2x2 matrices that show that the identity is not valid”. Before Desi proposed her idea her group had arrived at a solution to the problem. She was not satisfied with the solution that her group had suggested. The alternative solution that was proposed by Desi would add extend their insights to other ways of solving the problem. Desi has shown that she has used deep strategy of cognitive engagement in learning.

The data about deep strategy aspect of cognitive engagement also came from the questionnaire. The two tables below present the mean of the students’ answers to each item in the pre-test and post-test. Overall, the mean value and standard deviation of the deep strategy aspect of cognitive engagement can be seen in table 4.3 below.

Table 4.3: Descriptive Statistics for the Deep Strategy Subscale of the SEMC in the Pre-Test and Post-Test (n=37)

<table>
<thead>
<tr>
<th>No. of items</th>
<th>Pre-test</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Standard deviation</td>
</tr>
<tr>
<td>7</td>
<td>3.39</td>
<td>0.88</td>
</tr>
</tbody>
</table>

As shown in table 4.3 above, the mean value of all items in the deep strategy subscale of cognitive engagement in the post-test (3.50) was higher than that in the pre-test (3.39). This trend suggests that the implementation of the ACE teaching cycle in the Elementary Linear Algebra course resulted in positive effect on the use of deep strategy in students’ learning process.

Table 4.4: Mean of the Students’ Answers to each Item of the Deep Strategy Subscale of the SEMC in the Pre-test and Post-test.

<table>
<thead>
<tr>
<th>No</th>
<th>Items</th>
<th>Mean Pre-test</th>
<th>Mean Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>When I learn mathematics, I would wonder how much the things I have learnt can be applied to real life.</td>
<td>3.22</td>
<td>3.19</td>
</tr>
<tr>
<td>2</td>
<td>When I learn new things, I would think about</td>
<td>3.65</td>
<td>3.84</td>
</tr>
</tbody>
</table>
what I have already learnt and try to get a new understanding of what I know.

3 When I read mathematics textbook, I would try to pick out those things which should be thoroughly understood rather than just reading next through. 3.97 4.05

4 I would try to connect what I learned in mathematics with what I encounter in real life or in other subjects. 3.41 3.32

5 I would spend out of class time to deepen my understanding of the interesting aspects of mathematics. 3.16 3.35

6 In learning mathematics, I always try to pose questions to myself and these questions would help me understand the core of mathematics. 3.19 3.32

7 I would use my spare time to study the topics we have discussed in the class. 3.16 3.41

From table 4.4 above can be seen that five of the items (item 2, 3, 5, 6, and 7) displayed an increase in the mean value from the pre-test to the post-test. These items were related to students’ efforts to deepen their understanding of the materials. So, there was an increase in the deep strategy that was used by students to understand the topics, especially on the five items. This result was probably caused by the ACE teaching cycle approach that gave the opportunity to students to think about what they had already learnt through the reflective journals homework, to learn from the textbook to prepare them to create concept maps, to explore the material through discussions, and to complete exercises inside and outside the classroom.

However, two of the seven items (item 1 and 4) showed a decreasing mean value in students’ responses from the pre-test to the post-test. These items were related to the application of mathematics in real life and to other subjects. This result may have been due to the material of the subject that did not explicitly involve the use of the concepts in real life or the role of the concepts in other subjects. Most concepts of this Elementary Linear Algebra course are about pure mathematics
like linear equation systems, vectors, matrix, vector spaces, and inner product space. This condition may be the cause of the slight decrease in the mean values of the two items.

So, analysis of both qualitative and quantitative data showed that the use of the ACE teaching cycle in the Elementary Linear Algebra course increase students’ deep strategy of cognitive engagement in the same direction as what researcher had expected.

4.2.1.3 Reliance Aspect of Cognitive Engagement

In this part I will discuss the results of the analysis about students’ reliance in learning. The purpose of this analysis is to evaluate the effect of the implementation of the ACE teaching cycle in the Elementary Linear Algebra course on students’ reliance. The data for this aspect was obtained from focus group interviews, classroom observations and the questionnaire. Some of the students’ responses to these issues that were identified in the focus group interviews about reliance and independence in mathematics learning will be presented first.

In focus group Febi revealed that,

The ACE teaching cycle has changed my approach in learning mathematics. In using this approach, I have to learn first before coming to class. Through this method, we were first asked to draw a concept map; but before we developed the concept map we had to first learn by ourselves. If we didn’t understand a concept, we couldn’t produce a concept map. So, through this method I have to learn by myself and not depend on the lecturer’s explanation.

Febi revealed that the use of the ACE teaching cycle in the Elementary Linear Algebra course had an effect to her way in learning. The strategy that had been implemented facilitated her to improve her ability to study by herself. The concept maps task that was completed by students before class has encouraged her to learn
the topics before she was involved in creating the concept maps. As a result, she had known the topics before these were presented by the lecturer in the class. So, her dependence on the lecturer’s explanations decreased.

Still in the focus groups, Yanti also expressed her opinion about the reliance aspect:

Before I studied using this method, I was very dependent on the teachers’ explanations. But now with this method, I was trying to learn the materials by myself and reduce my dependence on teachers. When I made a concept map I must have understood the materials first. So, I pushed myself to understand the materials before making the concept map. Through the reflective journal I could review all what I had learnt and through completing the exercises I could improve my understanding of the concepts.

The use of the ACE teaching cycle in the Elementary Linear Algebra course has resulted in a different learning experience for Yanti. In this course, she had the opportunity to learn not only from the lecturer’s explanations but also from other activities like reading textbooks, creating concept maps, discussing in groups, writing reflective journals, and completing exercises. Using this strategy, her dependence on the lecturer’s explanations in the class has been reduced. As a consequence of this, her ability to construct knowledge by herself has improved.

Zola also stated his opinion in the focus group as follows:

I think the ACE teaching cycle approach is suitable for my type of learning; when I am given tasks I will do them seriously. Honestly, at the beginning I found difficulty to make concept maps and reflective journals because they are something new to me. To produce a concept map I have to study hard; I read the topics several times until I really understood the concept. Through writing the reflective journal I become to better understand the material that I
had learnt. I often wrote a reflective journal first before I attempted the exercises. So, I feel that the learning process with this strategy is very effective.

Here, Zola revealed two things: reliance and independence. He said that he would learn seriously if he was given an assignment. This attitude reflected his reliance on the lecturer. The lecturer’s directions were important for him to start learning, to give him ways on what should he do, and to encourage him to learn by himself. What Zola said was reasonable; without the lecturer’s directions, he would not be compelled to make concept maps, to discuss in groups, to write reflective journals, and to complete exercises. On other hand, Zola also showed his independence in learning. He struggled to understand the topics by himself in order to be able to contribute in creating concept maps and discussing in his group.

The qualitative data that were revealed from students’ responses in the focus group interviews revealed the increasing independence in students’ learning. This fact showed that the use of the ACE teaching cycle in the Elementary Linear Algebra course affects students’ independence in learning. On other hand, the data also showed that students’ had trust in the lecturer’s instruction.

The information about students’ independence in learning was also obtained from students’ activities in the classroom. As an example, the researcher took concept maps presentation during Week 5 by Group B1. Concept maps presentation was a learning activity at the beginning of the class in every classroom meeting. A group was selected to present their concept maps in front of the class. The mathematics topic that they presented in Week 5 was about Determinants. Group B1 comprised three members, Eki, Vera, and Salsa. They shared the duties in presenting the concept map that they had created; Eki acted as moderator whilst Salsa and Vera acted as concept map presenters.
Salsa presented the concept map using PowerPoint. She explained the definition of determinant. Salsa also used the blackboard to provide additional explanations and examples. And then, the presentation was continued by Vera. She gave the explanation about the properties of determinants, cofactor expansion, Cramer’s rule and the application of determinants. Salsa and Vera presented their concept maps that they had conscientiously in a systematic manner. What they had displayed in presenting the concept maps was the result of their efforts in learning. They had learnt the topic through learning individually and discussing in their small group to produce the concept maps. They were able to create and present the concept maps without any help from the lecturer. This showed that the use of the ACE teaching cycle approach in the Elementary Linear Algebra course has encouraged students to become independent in their learning. Figure 4.1 below shows Group B1 presenting the concept maps about Determinants.

![Figure 4.1: Group B1 presenting the concept maps about Determinants](image)

The data about the reliance aspect of cognitive engagement was also obtained from the questionnaire. The two tables below provide the mean of the students’ answers to each item of the reliance subscale of cognitive engagement of the
SEMC in the pre-test and post-test. The overall mean value and standard deviation of the reliance aspect of cognitive engagement can be seen from table 4.5 below.

Table 4.5: Descriptive Statistics for the Reliance Subscale of the SEMC in the Pre-Test and Post-Test (n=37)

<table>
<thead>
<tr>
<th>No. of items</th>
<th>Pre-test Mean</th>
<th>Pre-test Standard deviation</th>
<th>Post-test Mean</th>
<th>Post-test Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>3.70</td>
<td>0.67</td>
<td>3.78</td>
<td>0.62</td>
</tr>
</tbody>
</table>

Overall, as shown in table 4.5 above the mean value of all items in the post-test (3.78) was higher than in the pre-test (3.70). This trend suggests that the implementation of the ACE teaching cycle in the Elementary Linear Algebra course had an influence on the increase in the reliance aspect of cognitive engagement. Most of the items of the reliance aspect of cognitive engagement relate to students’ trust in the lecturer’s approach to the learning process. These items were not particularly intended to reveal students’ independence in learning. Specifically, the change in students’ responses to each item of the reliance aspect can be seen in table 4.6 below.

Table 4.6: Mean of the Students’ Answer to each Item of the Reliance Subscale of the SEMC in the Pre-Test and Post-Test (n = 37)

<table>
<thead>
<tr>
<th>No</th>
<th>Items</th>
<th>Mean Pre-test</th>
<th>Mean Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The best way to learn mathematics is to follow the lecturer’s instructions.</td>
<td>3.84</td>
<td>3.86</td>
</tr>
<tr>
<td>2</td>
<td>The most effective way to learn mathematics is to follow the lecturer’s instruction.</td>
<td>3.86</td>
<td>3.78</td>
</tr>
<tr>
<td>3</td>
<td>I would learn what the lecturer teaches.</td>
<td>4.07</td>
<td>4.03</td>
</tr>
<tr>
<td>4</td>
<td>I would learn in the way the lecturer instruct me</td>
<td>3.49</td>
<td>3.68</td>
</tr>
<tr>
<td>5</td>
<td>I would solve problems in the same way as the lecturer does.</td>
<td>3.51</td>
<td>3.78</td>
</tr>
<tr>
<td>6</td>
<td>I solve problems according to what the lecturer teaches.</td>
<td>3.86</td>
<td>3.95</td>
</tr>
<tr>
<td>7</td>
<td>In the learning mathematics, no matter what the lecturer says, I will follow accordingly.</td>
<td>3.30</td>
<td>3.38</td>
</tr>
</tbody>
</table>
From table 4.6 above it can be seen that there was an increase in the mean value in five of the seven items (item 1, 4, 5, 6, and 7). These items relate to the instructions and examples that were given by the lecturer during the teaching and learning process. Based on these students’ responses, it appears that as consequence of the use of the ACE teaching cycle students tended to follow the directions and examples that were given by the lecturer. Students probably expected the lecturer to give directions and advice to them on how to learn individually, to create concept maps, to discuss the mathematics problem solving, to do exercises, and to write reflective journals. All of these directions have an effect on how the students learn.

However, a decrease in the mean value was also observed for two items (items 2 and 3), with a larger decrease for item 2. The decrease in the mean value for item 2 (the most effective way to learn mathematics is to follow the lecturer’s instruction) was not surprising because in the ACE teaching approach the lecturer’s role in giving instructions was smaller than in the traditional approach. In ACE teaching model, the lecturer only had 40 – 50 minutes out of a total of 150 minutes during each session to give the instructions in the classroom. The remaining time was used for concept maps presentation and group discussions. Students’ responses to this item showed that the use of the ACE teaching cycle approach had resulted in a decline in students’ reliance on lesson instructions that were given by the lecturer. In other words, the approach had increased students’ independence in learning.

So, analysis of both qualitative and quantitative data showed that the use of the ACE teaching cycle approach in the Elementary Linear Algebra course increase students’ independence in learning and decrease students’ reliance on knowledge from the lecture directly. The data also showed an increase of students’ reliance on lecturer’s direction in the classroom.
4.2.2 Students’ Affective Engagement

Affective engagement is closely related to students’ reactions to the learning environment like, high level of interest, enjoyment, positive attitude towards learning, boredom, happiness, feelings of belonging, etc. (Chapman, 2003; Pierce, Kaye, & Anastasios, 2005). In this study, students’ affective engagement would be seen through four dimensions namely, interest, achievement orientation, anxiety, and frustration (Kong et al., 2003; Miserandino, 1996).

4.2.2.1 Interest Aspect of Affective Engagement

The purpose of analysing the data in this section was to study the change on the interest aspect of students’ affective engagement before and after the use of the ACE teaching cycle in the Elementary Linear Algebra course. The researcher expected that the use of this approach would improve students’ interest in learning mathematics. The data for this analysis came from focus group interviews (qualitative data) and from the questionnaire (quantitative data). The qualitative data will be analysed first.

In focus groups, Eki revealed his interest in learning mathematics using the ACE teaching cycle approach by saying, “I became more interested in studying mathematics. One important thing was that I was ready to attend classes.” Explicitly, Eki revealed that the strategy that was implemented in the Elementary Linear Algebra course affected his interest in learning. He also stated that the ACE teaching cycle had encouraged him to learn before class, so he could participate well in the class.

Next, Budi also revealed his opinion that relates to interest: “This approach is very suitable for my learning style, because the approach gave attention to self-learning.” This Budi’s response showed that he had improved interest to be involved in learning Elementary Linear Algebra using the ACE teaching cycle because the approach accommodated the procedures that he liked. As consequence of his interest, he felt that learning mathematics was an enjoyable
activity and encouraged him to be fully involved in learning, although at first he felt awkward. Related to this, Bayu stated that “From one week to another week I became familiar with this method. Although at the beginning, I felt worried about how to produce a good concept map or how to make a good reflective journal.”

In another instance in focus group interviews, Yanti revealed her interest by saying, “About the time for learning, my learning time increased with this method and I became more intensive in learning”. Allocating more time for learning would give her the opportunity to understand a topic better. What Yanti said reflected her attention to focus in learning. This fact showed that Yanti had improved interest in learning as a consequence of the use of the ACE teaching cycle approach in the Elementary Linear Algebra course.

Quantitative data from the closed questionnaire also revealed the interest aspect of students’ affective engagement. The two tables below summarise the mean of the students’ answers to each item of the interest subscale of the SEMC in the pre-test and post-test. Overall, mean values and standard deviations of the interest aspect of affective engagement are given in the table below.

Table 4.7: Descriptive Statistics for the Interest Subscale of the SEMC in the Pre-Test and Post-Test (n=37)

<table>
<thead>
<tr>
<th>No. of items</th>
<th>Pre-test</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Standard deviation</td>
</tr>
<tr>
<td>6</td>
<td>4.02</td>
<td>0.76</td>
</tr>
</tbody>
</table>

As shown in table 4.7 above the mean value of all items in the post-test (4.17) was higher than that in the pre-test (4.02). This finding suggests that the implementation of the ACE teaching cycle in the Elementary Linear Algebra course had the same effect as the researcher’s expectations about students’ interest in learning mathematics. More details about this outcome could be seen in table 4.8 below.
Table 4.8: Mean of the Students’ Answers to each Item of the Interest Subscale of the SEMC in the Pre-Test and Post-Test (n = 37)

<table>
<thead>
<tr>
<th>No</th>
<th>Items</th>
<th>Mean</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pre-test</td>
<td>Post-test</td>
</tr>
<tr>
<td>1</td>
<td>In the mathematics class, I find the mathematics knowledge interesting and mathematics learning is enjoyable.</td>
<td>4.05</td>
<td>4.27</td>
</tr>
<tr>
<td>2</td>
<td>I find mathematics learning pleasurable and I am interested in solving mathematics problems.</td>
<td>3.95</td>
<td>4.11</td>
</tr>
<tr>
<td>3</td>
<td>I feel a sense of satisfaction when I do mathematics exercises in class.</td>
<td>4.70</td>
<td>4.68</td>
</tr>
<tr>
<td>4</td>
<td>I am always curious to learn new things in mathematics and I find learning mathematics enjoyable.</td>
<td>3.89</td>
<td>4.03</td>
</tr>
<tr>
<td>5</td>
<td>I feel excited when we start a new topic in mathematics.</td>
<td>3.68</td>
<td>3.92</td>
</tr>
<tr>
<td>6</td>
<td>I am very interested to know how to solve new mathematics problems. Mathematics always gives me pleasure.</td>
<td>3.86</td>
<td>3.97</td>
</tr>
</tbody>
</table>

In table 4.8 above it is seen that the mean value increased for almost all items. The highest increase was in item 5: “I feel excited when we start a new topic in mathematics.” The use of the ACE teaching cycle approach had influenced students’ readiness to learn new topics. They were happy to learn a new topic. Their pleasure to learn new topics was probably caused by the approach used in the teaching and learning process that facilitated them to directly and intensively interact with the topics of the course so that they had the desire to learn other topics further. This fact is different from my previous experience as a lecturer, where most of the students felt worried to learn a new topic.

The decrease in the mean value occurred only for item 3: “I feel a sense of satisfaction when I do mathematics exercises in class”. Mean value in the pre-test was 4.70 while in the post-test the mean was 4.68. The difference of between these two means is very small, with the two scores almost having the perfect value of 5, suggesting that most of the students chose the option 5 (almost always)
for item 3 in the pre-test and post-test. In the pre-test, most of the students indicated that they felt a good sense of satisfaction when they did mathematics exercises in class before the ACE teaching cycle approach was implemented. In the post-test, there was a similar trend in students’ responses to the item. So, it may be concluded that most of the students had a good sense of satisfaction in doing mathematics exercises before and after the use of the ACE teaching cycle approach.

So, the analysis of both qualitative and quantitative data showed that the use of ACE teaching cycle had the same improved effect on the students’ interest in learning mathematics as that expected by the researcher.

4.2.2.2 Achievement Orientation Aspect of Affective Engagement

The purpose of analysing data in this section is to evaluate the effect of the use of the ACE teaching cycle in the Elementary Linear Algebra course on the achievement orientation aspect of students’ affective engagement. As a researcher, my expectation was that the use of the approach would have a positive effect on students’ achievement orientation. The analysis was performed on the qualitative and quantitative data. The qualitative data would be analysed first.

In focus group interviews, students expressed their effort in learning like what Vera said,

The difficulty that I found in learning with this method was that it was difficult to understand the new materials, because I had to learn the materials by myself first. I had to learn slowly to understand the concepts. So, I needed much time to understand the materials. Sometime I learnt the materials from the textbook over and over again until I understood.

Vera realized that she faced difficulty in learning, especially to learn new topics. This condition did not prevent her from continuing learning. Although slower, she
continued learning to understand the material. This behaviour showed that she displayed achievement orientation in learning.

Still on focus group interviews, Budi also revealed his achievement orientation by saying that “This approach encourages me to study hard. I had allocated more time to learn with this approach.” He expressed that the implementation of the ACE teaching cycle in the Elementary Linear Algebra had encouraged him to be serious in learning so that he could achieve his learning aims. By working hard and allocating more time gave him the opportunity for him to learn more concepts and to deepen his understanding.

The quantitative data from questionnaire also revealed about the achievement orientation aspect of affective engagement. The two tables below summarise the mean values of the students’ responses to each item of the achievement orientation subscale of the SEMC in the pre-test and post-test. The overall mean values and standard deviations of the achievement orientation subscale can be seen in table 4.9 below.

Table 4.9: Descriptive Statistics for the Achievement Orientation Subscale of the SEMC in the Pre-Test and Post-Test (n=37)

<table>
<thead>
<tr>
<th>No. of items</th>
<th>Pre-test</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Standard deviation</td>
</tr>
<tr>
<td>6</td>
<td>4.54</td>
<td>0.63</td>
</tr>
</tbody>
</table>

Students’ responses to the achievement orientation items, shown in table 4.9, revealed that most of the students selected option 4 (often) or 5 (almost always) for all items. This can be seen from the mean for both the pre-test and the post-test (4.54 and 4.50). These mean values showed a slight decrease in students’ responses to the achievement orientation aspect of affective engagement. This result was not in accordance with the expectations of the researcher who had expected an increase in this aspect, but based on both the mean values it can be said that the students displayed satisfactory achievement orientation before and
after the use of the ACE approach. As a researcher I saw that there was no significant change in the achievement orientation aspect of affective engagement. In other words, the implementation of the ACE teaching cycle in the Elementary Linear Algebra course did not change students’ achievement orientation significantly. Further details about students’ responses in both the pre-test and post-test can be seen in table 4.10 below.

Table 4.10: Mean of the Students’ Answers to each Item of the Achievement Orientation Subscale of the SEMC in the Pre-Test and Post-Test (n = 37)

<table>
<thead>
<tr>
<th>No</th>
<th>Items</th>
<th>Mean</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pre-test</td>
<td>Post-test</td>
</tr>
<tr>
<td>1</td>
<td>Though mathematics learning is tough, I feel happy when I can finish the tasks.</td>
<td>4.46</td>
<td>4.49</td>
</tr>
<tr>
<td>2</td>
<td>Though mathematics learning is boring, I am happy when I get good result.</td>
<td>4.54</td>
<td>4.41</td>
</tr>
<tr>
<td>3</td>
<td>Learning mathematics is tough, but to get good result, the effort is worthwhile.</td>
<td>4.43</td>
<td>4.49</td>
</tr>
<tr>
<td>4</td>
<td>Learning mathematics is tough, but I am satisfied when I get good result after making an effort.</td>
<td>4.73</td>
<td>4.59</td>
</tr>
<tr>
<td>5</td>
<td>Learning mathematics is tough, but I am happy as long as I can get good result.</td>
<td>4.54</td>
<td>4.46</td>
</tr>
<tr>
<td>6</td>
<td>Though mathematics learning is tough, I get a sense of satisfaction when I get good result.</td>
<td>4.54</td>
<td>4.54</td>
</tr>
</tbody>
</table>

The table above shows that the mean value for all items in the pre-test and post-test were above 4. This trend suggests that most students had good achievement orientation in learning before and after the implementation of the ACE teaching cycle approach and the use of the approach was able to maintain the students’ achievement orientation in learning.

So, qualitative data revealed that the use of the ACE teaching cycle had encouraged students to study hard. While the quantitative data did not show an increase in the mean value from the pre-test to the post-test on all items, the mean
values were still high. This fact suggests that students had strived to understand
material more but still got the same reward from their success.

4.2.2.3 Anxiety Aspect of Affective Engagement

The purpose of analysing the data in this section was to evaluate the effects of the
use of the ACE teaching cycle in the Elementary Linear Algebra course on the
anxiety aspect of students’ affective engagement. I expected that the use of this
approach would result in a decrease in students’ anxiety levels in learning
mathematics. The data for this aspect came from focus groups (qualitative data)
and the questionnaire (quantitative data). The qualitative data will be analysed
first.

In the focus group interview, Zola revealed his opinion about the use of ACE
teaching model that relate to anxiety in learning.

Through this approach I could share my knowledge in mathematics
with other friends. I understood more if I could teach someone else. I
was happy learning mathematics using this approach. This teaching
model was suitable with my learning style. I just felt anxious to face
the test.

Zola’s opinion above reflected that the use of the ACE teaching cycle approach in
Elementary Linear Algebra course did not cause him any anxiety in learning. He
just felt anxious to face the test.

In focus group interviews Yanti stated,

From week to week I became more anxious, because the materials
became more complicated. I have learnt the materials at home but it
was still hard for me to understand. I got a lot of help from friends in
my group, this made me feel safe
Yanti felt anxious because she realized that if she couldn’t learn the topics properly, then she would face difficulty to follow further learning because the topics in mathematics are related to each other. But, she felt safe because she belonged to a supportive group that were ready to help her. This fact points to an indication that the use of the ACE teaching model had facilitated Yanti to reduce her anxiety in learning.

Still in the focus group other students revealed their anxiety in facing the test. Zola stated that “I always feel anxious before an examination.” Next, Eki said that “I will be anxious when I can’t solve a problem.” Many other students are like Zola and Eki, they become anxious to face exams. Students feel anxious before and during the examination because they don’t want to fail. This condition may have encouraged them to learn harder.

The data about anxiety also came from the questionnaire. All items in anxiety subscale related to test or examination. Students were required to respond to five items about the anxiety aspect of affective engagement. The questionnaire was administered to students on two occasions, before and after the implementation of the ACE teaching cycle. The two tables below presents the means of the students’ responses on the anxiety subscale of affective engagement of the SEMC in the pre-test and post-test. The overall mean values and standard deviations of the anxiety subscale can be seen in table 4.11 below.

Table 4.11: Descriptive Statistics for the Anxiety Subscale of the SEMC in the Pre-Test and Post-Test (n=37)

<table>
<thead>
<tr>
<th>No. of items</th>
<th>Pre-test</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Standard deviation</td>
</tr>
<tr>
<td>5</td>
<td>3.49</td>
<td>0.86</td>
</tr>
</tbody>
</table>

The table above shows that the mean values in both pre-test and post-test are relatively high at 3.49 and 3.46. Most of the students selected options 3 (sometimes) or 4 (often) for all items. So, this trend suggests that the anxiety experienced by students in facing the test either before or during the use of the
ACE teaching cycle approach was quite high. However, the use of the approach has resulted in a slight reduction of the students’ anxiety levels. This could be seen from the mean value of the post-test mean that was slightly lower than the mean value in the pre-test. The change was practically negligible. More details about the mean values of each item of the anxiety aspect of affective engagement in the pre-test and post-test can be seen in table 4.12 below.

Table 4.12: Means of the Students’ Responses to each Item of the Anxiety Subscale of the SEMC in the Pre-Test and Post-Test (n = 37)

<table>
<thead>
<tr>
<th>No</th>
<th>Items</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pre-test</td>
</tr>
<tr>
<td>1</td>
<td>I find myself very nervous during mathematics test.</td>
<td>3.22</td>
</tr>
<tr>
<td>2</td>
<td>I am worried in mathematics examinations.</td>
<td>3.35</td>
</tr>
<tr>
<td>3</td>
<td>During mathematics examinations, when I come across problems that I cannot comprehend, I will feel very nervous.</td>
<td>3.46</td>
</tr>
<tr>
<td>4</td>
<td>I am always afraid that I will get poor result in mathematics test.</td>
<td>3.78</td>
</tr>
<tr>
<td>5</td>
<td>During mathematics test, when I come across problems that I cannot solve, I will feel very anxious.</td>
<td>3.68</td>
</tr>
</tbody>
</table>

In table 4.12 above is seen that there was a decrease in the mean value for almost all the items. The mean value increased only for item 1, “I find myself very nervous during mathematics test”. This increase in the mean value was very significant, increasing from 3.22 in the pre-test to 3.38 in the post-test. However, as a lecturer I had expected that the level of their anxiety would have declined. I was surprised to observe this result. Why did this happen? According to Crowder (2011) the longer a student takes to prepare for a test the more nervous s/he becomes. In my teaching practice using the ACE teaching cycle approach, I found that students spent more time preparing for a test, similarly to what Crowder had speculated. According to Crowder (2011) the best advice to reduce nervousness
when preparing for a mathematics test is by revising the mathematics concepts slowly.

So, the qualitative data suggest that the use of the ACE teaching model did not trigger students’ anxiety in learning mathematics. The approach facilitated student to feel happy and safe. The qualitative and quantitative data that relate to the test suggest that students experienced some anxiety. From the quantitative data shown in table 4.11 above, there was a slightly decreased in the mean value of students’ responses in the post-test compared with their responses in the pre-test. This trend suggests that students’ level of anxiety that relate to test had slightly decreased. According to Peker (2009) one of the causes of anxiety in learning mathematics is due to negative experiences in the learning process like failing a test, difficulty in understanding a concept, limited support from the lecturer, etc. So, this trend suggests that the implementation of the ACE teaching cycle in the Elementary Linear Algebra reduced the students’ negative experiences in learning mathematics. This finding was similar to that of the researcher’s expectations.

4.2.2.4 Frustration Aspect of Affective Engagement

The purpose of analysing the data in this section was to evaluate the effects of the implementation of the ACE teaching cycle in the Elementary Linear Algebra course on the frustration aspect of students’ affective engagement. The expectation of the implementation of the approach was that students’ frustration in mathematics learning would be reduced. The data for this aspect came from focus groups (qualitative data) and the questionnaire (quantitative data).

In the focus group interviews, students were asked whether they felt frustrated when they learnt using the ACE teaching cycle approach. Some of them gave their response as follows: Budi’s response, “No, I didn’t feel frustrated when I learnt with this approach.” Yanti revealed that, “I just felt frustrated when I couldn’t solve the problem.” Zola also gave his response, “I usually got frustrated when I knew that I made a mistake in the test.” So generally, I could say that the students...
did not feel frustrated when they followed learning using the ACE teaching model.

Budi revealed that the learning activity which he followed did not cause him to feel frustrated. This suggests that Budi enjoyed the lessons and could follow the lessons well. Meanwhile, Yanti and Zola had almost similar feelings when they revealed that they felt frustrated only when they made mistakes in the test. Perhaps this is not uncommon source of frustration to most students studying mathematics.

The data about frustration were also obtained from the questionnaire. Students were required to respond to five items about the frustration aspect of affective engagement. The questionnaire was administered to students on two occasions, before and after the use of the ACE teaching cycle. The mean values and standard deviations for the items of the frustration aspect of affective engagement can be seen in table 4.13 below.

Table 4.13: Descriptive Statistics for the Frustration Subscale of the SEMC in the Pre-Test and Post-Test (n = 37)

<table>
<thead>
<tr>
<th>No. of items</th>
<th>Pre-test</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Standard deviation</td>
</tr>
<tr>
<td>5</td>
<td>1.75</td>
<td>0.76</td>
</tr>
</tbody>
</table>

From the descriptive statistics table above, the mean values of the frustration aspect of affective engagement is less than two. This finding suggests that most students selected options 1 (almost never) or 2 (seldom) from the five options that were provided. This finding suggests that the level of students’ frustration in learning mathematics was low before and during the use of the ACE teaching cycle. However, the mean value decreased from 1.75 in the pre-test to 1.66 in the post-test. This trend suggests that the level of students’ frustration only slightly decreased as a result of the use of the approach. The mean value of students’ responses to each item of the frustration aspect can be seen in table 4.14 below.
Table 4.14: Means of the Students’ Responses to each Item of the Frustration Subscale of the SEMC in the Pre-Test and Post-Test (n = 37)

<table>
<thead>
<tr>
<th>No</th>
<th>Items</th>
<th>Mean Pre-test</th>
<th>Mean Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I feel uncomfortable when the teacher starts a new topic.</td>
<td>2.24</td>
<td>2.14</td>
</tr>
<tr>
<td>2</td>
<td>I am tired of learning a new topic in class.</td>
<td>2.11</td>
<td>1.81</td>
</tr>
<tr>
<td>3</td>
<td>I do not like attending mathematics classes.</td>
<td>1.51</td>
<td>1.54</td>
</tr>
<tr>
<td>4</td>
<td>I dislike doing mathematics.</td>
<td>1.24</td>
<td>1.35</td>
</tr>
<tr>
<td>5</td>
<td>I am tired of learning mathematics.</td>
<td>1.65</td>
<td>1.46</td>
</tr>
</tbody>
</table>

In table 4.14 above it can be seen that the mean values of students’ responses to each item are in the range of 1 to 2. This trend reflected the low levels of students’ frustration before and during the use of the ACE teaching cycle. However, from the table it can be seen that the mean values of some items had increased but had decreased for other items. The most notable decrease in the mean value was for item 3, “I am tired of learning a new topic in class.” The decrease in this mean value could have been due to the students having learnt the new topics through a series of activities that they had followed step by step. First, they read the textbook as a preparation to create the concept maps. Then, they were involved in creating the concept maps about the topics. Next, they were involved in discussions about the topic in the class. Then, they listened to the lecturer’s explanations about the topics. Finally, they wrote reflective journals and completed homework exercises on the topics. So, they did not learn the new topics at one go but gradually. This approach may have had an effect on the level of the students’ tiredness in learning.

So, from the qualitative and quantitative data it may be deduced that students felt frustrated in learning mathematics before and during the use of the ACE teaching cycle approach. The qualitative data revealed that the level of students’ frustration during the use of the approach had only slightly decreased. This finding suggests that the use of the ACE teaching cycle had contributed to lowering of students’ frustration in learning, similarly to what the researcher had expected.
4.2.3 Students’ Behavioural Engagement

Behavioural engagement is closely related to student participation in the classroom. Active participation in the classroom is demonstrated by: compliance with classroom procedure, taking initiative in the group and classroom, becoming involved in the classroom activities, asking questions, regularly attending class, and comprehensively completing assignments (Chapman, 2003; Skinner & Belmont, 1993). According to Kong et al. (2003) students’ behavioural engagement in learning could be seen through two aspects, namely; attentiveness and diligence. These two terms will be discussed to describe students’ behavioural engagement in learning.

4.2.3.1 Attentiveness Aspect of Students’ Behavioural Engagement

The purpose of analysing the data in this section was to evaluate the effects of the use of the ACE teaching cycle in the Elementary Linear Algebra course on the attentiveness aspect of students’ behavioural engagement. The data for this approach came from focus group interviews, classroom observations (qualitative data), and the questionnaire (quantitative data).

In the focus group, Febi revealed her attentiveness in learning using ACE teaching approach by saying,

Through discussing in the class we could share information and knowledge and through journal writing I could review the topics. I got the explanation not only from lecture but also from friends. I achieved deeper understanding of the topics through doing all tasks.

Febi stated that she involved herself actively in the learning activities, like doing all the tasks, and by being active in discussions. She also revealed that she benefited from learning with this approach by sharing ideas in discussions, reviewing the materials, and in the process achieved deeper understanding. This
fact suggests that the students were engaged in the teaching and learning procedures that were implemented in the course.

Still in the focus groups, Budi said,

About discussions in the class, if we were given a lot of problems to solve then we shared the problems so that each of us could work individually first, and then we discussed them together. So, in the group there was mutual exchange of information that increased my ability to solve the problem.

Budi explained his group’s strategy to discuss the problems. This practice was an indication that all of them had paid attention to be involved to solve the mathematical problems that they faced.

The attentiveness aspect of behavioural engagement could also be seen through classroom observations. Figure 4.2 below presents the classroom atmosphere during Week 4 when all groups held discussions while solving the mathematics problems. All groups in the class were involved in active discussion. Through discussions in groups, they had the opportunity to share knowledge in their effort to solve the problems that they faced. This finding suggests that the use of the ACE teaching cycle approach had affected students’ attentiveness in learning.
The data about this attentiveness aspect also came from the questionnaire. Students were required to respond to six items about the attentiveness aspect of their behavioural engagement. The questionnaire was administered to students on two occasions, before and after the use of ACE teaching cycle. The mean values and standard deviations of the students’ responses to all items of the attentiveness aspect can be seen in Table 4.15 below.

### Table 4.15: Descriptive Statistics for the Attentiveness Subscale of the SEMC in the Pre-Test and Post-Test (n = 37)

<table>
<thead>
<tr>
<th>No. of items</th>
<th>Pre-test</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Standard deviation</td>
</tr>
<tr>
<td>6</td>
<td>3.79</td>
<td>0.83</td>
</tr>
</tbody>
</table>

As shown in Table 4.15 above the mean values of the attentiveness aspect of students’ behavioural engagement was 3.79 in the pre-test and 3.78 in the post-test; these values are almost same. Before the use of the ACE teaching cycle the level of students’ attentiveness in learning mathematics was high and after the use of the approach their attentiveness level was still high. So, the researcher could
deduce that the use of the approach maintained the students’ high level of attentiveness. Further details about the students’ response to all of the items can be seen in table 4.16 below.

Table 4.16: Mean of the Students’ Responses to each Item of the Attentiveness Subscale of the SEMC in the Pre-Test and Post-Test (n = 37)

<table>
<thead>
<tr>
<th>No</th>
<th>Items</th>
<th>Mean</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pre-test</td>
<td>Post-test</td>
</tr>
<tr>
<td>1</td>
<td>I listen to the lecturer’s instruction attentively.</td>
<td>3.92</td>
<td>3.97</td>
</tr>
<tr>
<td>2</td>
<td>In the discussion of new topics, I take an active part and raise my points.</td>
<td>2.97</td>
<td>3.22</td>
</tr>
<tr>
<td>3</td>
<td>I really make an effort in the mathematics lesson.</td>
<td>4.16</td>
<td>4.08</td>
</tr>
<tr>
<td>4</td>
<td>I concentrate very hard when the teacher introduces new mathematical concepts.</td>
<td>4.05</td>
<td>4.05</td>
</tr>
<tr>
<td>5</td>
<td>I will use every means to understand what the lecturer teaches in mathematics.</td>
<td>4.30</td>
<td>3.89</td>
</tr>
<tr>
<td>6</td>
<td>I always take part in the discussion in the mathematics class.</td>
<td>3.32</td>
<td>3.46</td>
</tr>
</tbody>
</table>

Table 4.16 above shows a significant increase in the mean values for item 2, “In the discussion of new topics, I take an active part and raise my points”, and for item 6, “I always take part in the discussion in the mathematics class.” The students’ responses to these two items suggest that the use of the approach has had the effect of improving their attentiveness in learning especially in relation to discussion activities. The improvement in these items was possible because the ACE teaching cycle approach enabled them to be actively involved in discussion activities.

There was significant decrease in the mean value for item 5, “I will use every means to understand what the lecturer teaches in mathematics.” The mean value of this item decreased from 4.30 in the pre-test to 3.89 in the post-test. The decrease in this mean value was not unexpected because the lecturer did not spend much time in explaining the materials in the ACE teaching cycle approach. Students did not depend on the lecturer to receive explanations about the topics.
A decrease in the mean value was also observed in item 3, “I really make an effort in the mathematics lesson.” The mean value of this item decreased slightly from 4.16 in the pre-test to 4.08 in the post-test. These mean values were slightly above 4, suggesting that most of the students gave their responses as option 4 (often) or as option 5 (almost always). So, most of the students really made an effort in learning mathematics not only in learning with the ACE teaching cycle but also in the learning before the implementation of the ACE teaching cycle.

4.2.3.2 Diligence Aspect of Students’ Behavioural Engagement

The purpose of analysing the data in this section was to evaluate the effects of the use of the ACE teaching cycle in the Elementary Linear Algebra course on the diligence aspect of students’ behavioural engagement. As a lecturer and researcher in this study, my expectation was that the use of this approach in my teaching practice would have a positive effect on the students’ diligence in mathematics learning. The data for this approach came from focus group interviews and the questionnaire.

In focus group interview Zola revealed that “To produce a concept map I have to study hard; I read the material several times until I really understood the concept.” This comment showed Zola’s persistence in learning. He had the willpower to understand the topics. He realized that if he didn’t understand the topics then he would face difficulty in developing the concept maps.

Budi also gave his response which related to diligence:

This approach encourages me to study hard. In the conventional classroom there are no concept maps, and there are no reflective journals. It only had exercises. I had allocated more time to learn with this approach.
Budi revealed that the use of ACE teaching cycle in the Elementary Linear Algebra had influenced his way of learning. He became more diligent and allocated more time to study.

The persistence in learning was also revealed by Yanti:

> When I drew a concept map I had to understand the topics first. So, I pushed myself to understand the topics before drawing the concept map. In other subjects that were taught in the conventional way, if I found difficulty to solve a problem or to understand a concept I didn’t care and I would not study hard for it, because I knew the lecturer would give the complete explanation in the classroom.

Yanti also stated that the teaching approach had encouraged her to study hard so that she was able to understand the materials and complete her tasks. She also indicated her reaction in facing difficulties in other subjects that were taught conventionally; she just waited for the lecturer to explain the issues that were difficult to understand.

Febrina also revealed her diligence in learning by saying, “In learning I am not only used to the main textbook but also I used other books and internet facility to support my learning. I did that if I need more explanations”. Her diligence in learning showed that Febi had engagement in learning mathematics. She was encouraged to better understanding of the topics deeper through learning from various sources.

The data about this diligence aspect also came from the questionnaire. Students were required to provide their responses to six items of the diligence aspect of students’ behavioural engagement. The questionnaire was administered to students on two occasions, before and after the use of ACE teaching cycle. Table 4.17 below shows the mean values and standard deviation of students’ responses to all items of the diligence aspect of students’ behavioural engagement.
Table 4.17: Descriptive Statistics for Diligence Subscale of the SEMC in the Pre-Test and Post-Test (n = 37)

<table>
<thead>
<tr>
<th>No. of items</th>
<th>Pre-test Mean</th>
<th>Pre-test Standard deviation</th>
<th>Post-test Mean</th>
<th>Post-test Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>3.79</td>
<td>0.84</td>
<td>3.94</td>
<td>0.75</td>
</tr>
</tbody>
</table>

The table above shows that the mean value of students’ response on the diligence aspect of behavioural engagement improved from 3.79 in the pre-test to 3.94 in the post-test. This increase suggests that the use of the ACE teaching cycle had affected students’ diligence in mathematics learning. This was possible because the approach had facilitated them to be involved in learning through various activities. Table 4.18 below presents the mean values of the students’ responses on each item of the diligence aspect.

Table 4.18: Mean of the Students’ Responses to each Item of the Diligence Subscale of the SEMC in the Pre-Test and the Post-Test (n = 37)

<table>
<thead>
<tr>
<th>No</th>
<th>Items</th>
<th>Mean Pre-test</th>
<th>Mean Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>For difficult problem, I would study hard until I understand them.</td>
<td>3.95</td>
<td>3.92</td>
</tr>
<tr>
<td>2</td>
<td>If I cannot arrive at the right answer straight away. I will try again later.</td>
<td>3.70</td>
<td>3.86</td>
</tr>
<tr>
<td>3</td>
<td>If I cannot tackle a problem, I would try again later.</td>
<td>3.59</td>
<td>3.78</td>
</tr>
<tr>
<td>4</td>
<td>If I make mistake in solving problems, I will work until I have corrected them.</td>
<td>3.84</td>
<td>4.00</td>
</tr>
<tr>
<td>5</td>
<td>If I work on problems persistently, I am sure that I will get the right answer.</td>
<td>4.19</td>
<td>4.24</td>
</tr>
<tr>
<td>6</td>
<td>If I cannot solve a problem right away, I will persist in trying different methods until I get the solution.</td>
<td>3.49</td>
<td>3.81</td>
</tr>
</tbody>
</table>

In table 4.18 above, an increase in the mean value occurred for almost all items, except for item 1 where there was a slight decrease. The increasing mean values for the other five items was an indication that students tended to be more...
diligently in their learning as a result of the implementation of the ACE teaching cycle. This improvement was possible because the ACE teaching cycle approach provided opportunities to students to be actively involved in the teaching and learning process. So, the use of the approach has had the same influence on the diligence aspect of behavioural engagement that expected by the researcher.

4.2.4 Summary of the Cognitive Engagement, Affective Engagement, and Behavioural Engagement

The use of the ACE teaching cycle approach in the Elementary Linear Algebra course at Padang State University for one semester has influenced the students’ engagement in learning. The influences could be seen from the qualitative and quantitative data in the three domains of students’ engagement in learning namely, cognitive, affective, and behavioural.

The qualitative data revealed the effects of the use of the ACE teaching cycle approach on the three domains of cognitive engagement. On cognitive engagement, students displayed their engagement through three aspects namely, surface strategy, deep strategy, and reliance. The data revealed that the students used both surface strategy and deep strategy in their efforts to engage in the teaching and learning process. The qualitative data also revealed that students became more independent in their learning and their dependence to acquire knowledge from the lecturer decreased. On affective engagement, students demonstrated their engagement through four aspects namely, interest, achievement orientation, anxiety, and frustration. The qualitative data revealed that the use of the ACE teaching cycle approach has had impact on students’ engagement in learning in the following aspects: the students were more interested in learning; students were encouraged to study hard to achieve their goals; students felt happy and safe in learning; and the level of students’ frustration tended to diminish. On behavioural engagement, students demonstrated their engagement through two aspects namely, attentiveness and diligence. The data about these aspects revealed that the use of the approach had impact on
students’ engagement with students demonstrating their active involvement in the teaching and learning process and in their diligence in learning.

The quantitative data that were obtained from the Student Engagement in the Mathematics Classroom questionnaire also showed the effects of the use of the ACE teaching cycle approach in the Elementary Linear Algebra course. Students gave their responses to the questionnaire on two occasions, before and after the use of the approach in their learning process. Table 4.19 below presents the mean values of all aspects of engagement in the pre-test and the post-test.

Table 4.19: Mean Values and Standard Deviations of the Aspects of Engagement of the SEMC in the Pre-Test and Post-Test (n = 37)

<table>
<thead>
<tr>
<th>Aspects of Engagement</th>
<th>Pre-test</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Standard deviation</td>
</tr>
<tr>
<td>Cognitive Engagement:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface Strategy</td>
<td>2.98</td>
<td>1.02</td>
</tr>
<tr>
<td>Deep Strategy</td>
<td>3.39</td>
<td>0.88</td>
</tr>
<tr>
<td>Reliance</td>
<td>3.70</td>
<td>0.67</td>
</tr>
<tr>
<td>Affective Engagement:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interest</td>
<td>4.02</td>
<td>0.76</td>
</tr>
<tr>
<td>Achievement Orientation</td>
<td>4.54</td>
<td>0.63</td>
</tr>
<tr>
<td>Anxiety</td>
<td>3.49</td>
<td>0.86</td>
</tr>
<tr>
<td>Frustration</td>
<td>1.75</td>
<td>0.76</td>
</tr>
<tr>
<td>Behavioural Engagement:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attentiveness</td>
<td>3.79</td>
<td>0.83</td>
</tr>
<tr>
<td>Diligence</td>
<td>3.79</td>
<td>0.84</td>
</tr>
</tbody>
</table>

The researcher had expected that the mean values of seven aspects (surface strategy, deep strategy, reliance, interest, achievement orientation, attentiveness, and diligence) of the total of nine aspects of engagement to increase. An increase in the mean values occurred for most of the aspects of engagement except for achievement orientation and attentiveness. However, the mean values of these two aspects were slightly decreased although their mean values were high before and
after the use of the approach. On the aspects of anxiety and frustration, the mean value of the two aspects was seen to decrease. This result is similar to what the researcher had expected. So, based on this quantitative data, the researcher can say that the use of the ACE teaching cycle approach in the Elementary Linear Algebra course has had an effect on students’ engagement in learning, with students becoming more engaged in their learning.

So, based on the qualitative and quantitative data the researcher can say that the implementation of the ACE teaching cycle approach in the Elementary Linear Algebra course has had an effect on students’ engagement in learning, as the approach has encouraged students to improve their engagement in learning.

4.3 The effects of the Use of the ACE Teaching Cycle on Students’ Learning

In this section students’ learning will be discussed related to students’ understanding of concepts and procedures, students’ abilities in problem solving, and students’ abilities in communication. These aspects of students’ learning would be evaluated through classroom observations, students’ reflective journals, and students’ concept maps. From the classroom observations and students’ reflective journals, the researcher obtained information about students’ understanding of concepts and procedures, students’ abilities in problem solving, and students’ abilities in communication. From the students’ concept maps, the researcher obtained information about students’ understanding of concepts and procedures in their preparation to discuss the materials in the classroom.

4.3.1 Students’ Understanding of Concepts and Procedures

The analysis of the data regarding students’ understanding of concepts and procedures will be presented based on data collected using classroom observations, students’ reflective journals, and concept maps:
4.3.1.1 Classroom Observations

The purpose of this section is to investigate students’ understanding of concepts and procedures as consequence of the use of the ACE teaching cycle in the Elementary Linear Algebra course. The data obtained through classroom observations from the discussion activities of group B during Week 2 and Week 6 will be used.

During the Week 2 discussions, students’ conversations revealed that at the beginning of the discussion to solve the problems, they had different understandings about the materials. Some of them did not sufficiently well understand the important concepts and procedures. Others had good understanding of the concepts and procedures in the materials. This situation was evident in the conversation between Revi and Salsa about the relationship between a linear equation system and a graph.

Revi revealed,

I don’t understand how to solve this problem without finding all values of the variables.

Salsa responded,

We can see the solving through the position of the lines on the graph; if all lines are parallel that means there is no solution to the system.

This simple conversation helped Revi to see the relationship between a linear equations system and the positions of their lines on a graph, the solution of linear equations system problems could not only be seen through the algebra manipulation of each variable but also could be known through the relative positions of the lines.
The improvement of their understanding could also be seen through this conversation between Eki and Salsa. Eki revealed that,

I am stuck here, how to do the next elementary row operation? I am not sure.

Eki didn’t know completely the characteristics of a reduced row echelon matrix and how to solve a system of linear equations using the Gauss-Jordan elimination procedure; as a result he couldn’t do the elementary row operation correctly.

Salsa helped Eki by stating,

All entries in row 2 are zero. We must interchange this row with the last row.

What Salsa said helped Eki to solve the problem. Eki realized his weakness in solving the linear equation system problem using the procedure of Gauss-Jordan elimination. So, through this group discussion Eki had the opportunity to increase his understanding of procedures on how to use the Gauss-Jordan elimination.

The improvement of students’ understanding of concepts and procedures was also observed in the group discussion activity during Week 6. Their discussions revealed that students helped each other in learning the materials, as in the example of the following conversation between Salsa and Revi.

Salsa expressed her doubts on how to solve a linear equations system using Cramer’s rule,

In using Cramer’s rule, I only remember that we have to change something. But, I don’t know which ones that I have to change.

Revi gave Salsa an explanation on how to use Cramer’s rule to solve the linear equations system problem. Revi said,

If we want to find the value of variable \(x_1\), we can do the following steps: Firstly, we must change the first column of the coefficient
matrix with the constant matrix so we get a new matrix. Then, we count its determinant. Finally, the value of $x_1$ can be obtained by dividing the determinant of coefficient matrix by the determinant of the new matrix. We can find the value of other variables through similar way.

The assistance that was provided by Revi was about the procedure on how to solve the linear equations system problems using Cramer’s rule. This assistance that was provided by Revi, facilitated Sri’s understanding of how to use Cramer’s rule to solve the problem of linear equations system.

So, the implementation of the ACE teaching cycle in the Elementary Linear Algebra course has enabled students to increase their understanding of concepts and procedures when solving problems. Through this approach they had the opportunity to learn not only from the lecturer but also from their friends. In this approach, they had flexibility in immediately asking their friends’ questions when they faced a problem as in the conversation above. The conversation among students during the discussions facilitated them in improving their understanding of concepts and procedures in mathematics.

4.3.1.2 Students’ Reflective Journals

In this study, students were asked to write reflective journals for homework about what they had learnt during the week. The instructions that were given to the students were, “Please write on at least two pages of folio-size paper about what mathematics knowledge that had acquired during the one week of learning mathematics”. The use of this reflective journal in this section is to describe students’ knowledge that relate to their understanding of the mathematics concepts and procedures. For the purpose of analysis, the researcher used the reflective journal written by Febi for topics covered during Week 12. Figure 4.3 below is the reflective journal that was written by Febi.
Figure 4.3: Page 1 of Febi’s reflective journal for Week 12
We have learnt a lot of things in the chapter of Vector Space. Last week, we learnt about Row Space, Column Space, Rank, and their application to find basis. This week, we have learnt Inner Product Space, Norm and Angle in Inner Product Space, and Orthogonality. Now, I will express my knowledge about this week’s topics. Firstly, I will present the definition of inner product space.

Definition:
Inner product on a real vector space V is a function that associates a real number \(<u, v>\) with each pair of vectors u and v in V in such a way that the following axioms are satisfied for all vectors u, v, and w in V and all scalars k.
1. \(<u, v> = <v, u>\>
2. \(<u+v, w> = <u, w> + <v, w>\>
3. \(<ku, v> = k<u, v>\>
4. \(<v, v> \geq 0, \text{ and } <v, v> = 0 \text{ if and only if } v = 0.\>

A real vector space with an inner product is called a real inner product space.

I will show some examples.

If u = (u_1, u_2, \ldots, u_n) and v = (v_1, v_2, \ldots, v_n) are vectors in \(R^n\), then the formula \(<u, v> = u.v = u_1v_1 + u_2v_2 + \ldots + u_nv_n\) defines \(<u, v>\) to be the Euclidean inner product on \(R^n\).

And now, we will see weighted Euclidean inner product.

If \(w_1, w_2, \ldots, w_n\) are positive real numbers, which we call weight, and if u = (u_1, u_2, \ldots, u_n) and v = (v_1, v_2, \ldots, v_n) are vectors in \(R^n\), then it can be shown that the formula \(<u, v> = w_1u_1v_1 + w_2u_2v_2 + \ldots + w_nv_nv_n\) defines an inner product on \(R^n\). It is called the weighted Euclidean inner product with weight \(w_1, w_2, \ldots, w_n\).

Inner product that resulted by matrix.
Let 

\[ u = \begin{pmatrix} u_1 \\ u_2 \\ \vdots \\ u_n \end{pmatrix} \quad \text{and} \quad v = \begin{pmatrix} v_1 \\ v_2 \\ \vdots \\ v_n \end{pmatrix} \]

be vectors in \( \mathbb{R}^n \) and let \( A \) be an invertible matrix \( n \times n \). If \( u.v \) is an Euclidean inner product in \( \mathbb{R}^n \), then the formula \( <u, v> = Au.Av = (Av)^tAu = v^tA^tAu \) defines an inner product on \( \mathbb{R}^n \).

At the beginning of her reflective journal, Febrina expressed that she has learnt a lot of things about several topics. Of course, through her learning process she would acquire knowledge and experiences about the topics. In another part of her journal, she explained about the definition of inner product space, norm, distance, and angle between two vectors in inner product space. Her explanations were supported by examples. The use of examples facilitated her understanding of the topic that was presented.

The definition and the axiom that were presented in the above reflective journal look similar to the definition and the axiom in the textbook. In her reflective journal writing, there is impression that she just copied the definition and axiom into her reflective journal. However, in mathematics is not easy to write mathematics terms using other symbols or other words, as it could result in a different meaning.

Through this reflective journal, Febi has shown her effort in learning. She re-opened her textbook and tried to write by herself the important things that she had learnt for one week. This reflection showed that the reflective journal task had encouraged her to learn the mathematics concepts and procedures.

So, the writing of reflective journals has facilitated students to explore what they have learnt. Before writing the reflective journals students would have gone through a series of learning activities on the topics. First, students learnt the topics individually using the textbook. Then, they held discussions in their small groups
to develop concept maps about the topics. Then, they attended the class and in the
classroom they had the opportunity again to learn the topics during the presenting
of the concept maps, lecturer’s presentation, and group discussions. Then, after
class they completed homework exercises about the topics. And finally, they
reflected on what they had learnt during the week. This would give them the
opportunity to deepen their understanding of the topics.

4.3.1.3 Concept Maps

Constructing mathematics concept maps was one of the homework activities that
students had to complete every week. They developed the concept maps about the
topics that would be discussed in class the following week. These topics were
something new for them. To be able to develop the concept maps they had to learn
the topics first through reading the book. The concept maps that they submitted as
homework was the result of their efforts outside the classroom. This section will
be discussed the data from the concept maps in their relation to the students’
learning.

For the analysis purposes, I chose the concept maps of one group for
investigation. The group that was selected was Group D1 that consisted of two
female students, Yanti and Tita. During the semester, 11 concept maps were
created by Group D1. I analysed three of these concept maps, one each for weeks
2, 5&6, and 10. The development of students’ ability in producing the concept
maps can be seen in the three figures below.
Figure 4.4: Concept map of week 2 topic (System of Linear Equations and Matrix) which was created by group D1

The concept map above is the first concept map that was developed by group D1. The concept map is very simple. They just connected the title of sections and subsections of the topic. The concept maps that they developed gave the impression that they produced the concept map with just a glimpse at the contents of the book. The figure above is not a concept map that was expected to be produced by students. On the concept map above, neither did the creators give any explanation of each concept nor did they describe the connection among the concepts.

As the semester progressed, group D1 displayed an improved ability in developing the concept map. This improvement is evident from the concept maps of week 5&6 about Determinant as seen in Figure 4.5 below.
On the concept map above, group D1 had tried to present the links between concepts for the topic of Determinants. This concept map is better than the concept map that they had produced in Week 2. On this concept map, they have presented some important concepts like definition of determinants, properties of determinant function, cofactor expansion, Cramer’s rule, inverse matrix, and the procedure for computing the determinant of a matrix using row reduction. This presentation showed that they had learnt the topics so that they knew the important concepts of determinants. The concept map that they were developed still had limitations, such as, not all important concepts were covered in the concept map, formulas and symbols were given without explanations, and they didn’t provide explanations on the lines that linked the concepts. The most important thing was that the concept map showed that the students had learnt the material and could identify the concepts before the material was discussed in class.
The improvement in their ability to develop the concept maps could also be seen through the way they developed the concept maps. At the beginning, they developed the concept maps in handwriting. In the weeks at the end of the course, group D1 produced their concept maps using power point software. Figure 4.6 below is a concept map of week 10 material that was developed by group D1.

Figure 4.6: Concept map of week 10 topic (Linear Independence) that was developed by group D1

The concept map above reflects the efforts of group D1 to understand the materials about Linear Independence. They were able to develop better concept maps from week to week. In the concept map above, the trend can be followed and the contents can be understood. The concept map also reflected that the creators were able to identify important concepts and link them properly. This fact indicated that they had involved in learning process to understand the contents of the topics.

Gradually, the concept maps that were produced by students increased in complexity as the semester progressed. The improvement in students’ ability in
developing the concept maps could also be seen by the way they developed the concept maps. In early weeks, they developed the concept maps using paper and pencil. In the last weeks, most of students had developed the concept maps using computer technology (power point software), while other still produced handwritten concept maps. The quality of students’ construction of concept maps provided indication of their improved preparation for mathematics topics that would subsequently be discussed in the lessons in class.

Students’ understanding on mathematical concepts will also be investigated using concept maps presentations. For analysis purposes, the researcher used the data from the concept maps presentation of Group B1 in Weeks 6. The mathematics topic that was presented in this concept maps presentation was about Determinants.

The members of Group B1 displayed their concept maps in front of the classroom. Their learning on the concepts was evident by their ability to construct the concept maps that contained links between mathematics ideas as seen in Figure 4.7 below and their ability to present the mathematics concept maps in front of the class.

Figure 4.7: Concept Map about the topic of Determinants that was presented by Group B1 in the classroom.
Students’ understanding on the concepts through this concept maps presentation was shown not only by the members of the presenting group but also by other students in the class. After the presentation, some students like Zola and Hilsa gave suggestions for improvement to the presenters. Zola’s suggestion was, "The concept map that was presented was pretty good, but I see there are still concepts that need to be connected, for example, there is no connecting line between matrix inverse and cofactors ". Hilsa gave her suggestion, “Vera said that $M_{ij}$ is a matrix; it is not a matrix but it is the determinant of the sub-matrix that remains after the $i$th row and $j$th column are deleted from $A$”. Zola and Hilsa paid careful attention to the concept map presentation so that they could give their ideas for improvement. In this respect, Zola and Hilsa have shown their understanding of the concepts.

The concept maps presentations triggered constructive discussions between students in the class. Through these discussions, the presenting group received useful inputs for improving their concept maps. For example, the following response was given in the Week 8 presentation, by a student who said, “The concept map is pretty good; it will be better if there is an explanation on the line that connects Vector Space and Subspace.” Another student gave a suggestion for correction of a misconception by stating, “On the explanation about the definition of linear combination in part $v = k_1v_1 + k_2v_2 + \ldots + k_nv_n$, the presenter said that $v_1$, $v_2$, …, $v_n$ are vector components of $V$; I think they are not vector components, but they are only vectors in vector space $V$.”

What was expressed by the two students reflected that they have paid attention to the concept map presentation and had understanding on the concepts. The inputs that were usually given to the presenters included corrections of misconceptions and misplaced concepts on the map, and additional information that should be included on the concept map. Actually, the benefits of all the inputs were not only for the presenters but also for all students in the class. So, the concept maps activity has encouraged them to learn and to improve their understanding of the mathematics concepts and procedures.
4.3.2 Students’ Ability in Problem Solving

The aim of this section is to investigate students’ ability in mathematics problem solving as consequence of the use of the ACE teaching cycle approach in Elementary Linear Algebra course. The data that was used to perform the analysis in this section came from the focus group interview and the classroom observations on the discussions of group B during Week 2 and Week 6.

In focus group, Budi revealed his ability and his group strategy in handling problem solving,

In problem solving, I always found easy problems and difficult problems to solve. When I found the difficult problems I got help from friend in the group. Our strategy to solve mathematical problems in the group; if we were given a lot of problems to solve then we shared the problems so that each of us could work individually first, and then we discussed them together. So, in the group there was mutual exchange of information that increased my ability to solve the problem.

Budi’s comment above reflected that the use of ACE teaching model had facilitated his ability to solve the hard mathematical problems that he faced through group discussion.

In the classroom observations on the discussions of group B during Week 2, the discussions that took place were about solving selected mathematics problems. Through the discussions, students had the opportunity to sharpen their ability in solving mathematics problems. As was observed in the group discussions, Salsa and Vera were involved in a conversation to evaluate their results in solving a linear equations system.

Salsa said,

What you did on number 2 is simpler than what I did Vera, you only used 5 elementary row operations.
Salsa revealed this conclusion after she compared her job with Vera’s job.

Vera gave her response,

Maybe you did not follow the procedure in using the elementary row operation to change its augmented matrix to the reduced row-echelon form.

Salsa said,

O ya, I did not pay attention to it, I would see.

Through this comparison, Salsa had the opportunity to improve her ability to solve the problem; she learnt about the technique which was used by Vera to solve the problem.

In the discussion during Week 2, they were active in finding and sharing ideas to get better answers when solving mathematics problems. Sharing ideas was really helpful for them to understand the topics and to solve the problems. After Vera’s assistance about how to use the elementary row operation in solving the linear equations system, Salsa was able help Eki who did not know how to complete his job. In solving the problem, Eka said,

I am stuck here. I am not sure what I have to do next.

Salsa gave her assistance,

You see, all entries on this row are zero, so you can interchange the row with the last row. Its meaning will not change.

Eki’s response,

Thanks Salsa, I understand how to do it now.

The assistance that was given by Salsa helped Eki to better understand how to use the elementary row operation to solve the linear equations system problem.
The time allocated for discussions was limited to only 50 minutes. During Week 2 discussions, they had used most of the time to work independently. As a result, there was not enough time for them to discuss all issues that emerged from the problems so that not all members understood the solving of the problems. At the end of the discussion, Vera said, “I still don’t understand yet how to decide if a system of linear equations has exactly one, infinite, or no solution by using the augmented matrix, but the time is over.” This experience indicated that they needed much more time to discuss so that all members in the group were better able to understand the topics.

During Week 6, each member of the group first solved different problems. On this occasion, there were five problems to be discussed. So, one student would attempt to solve one problem, after which they discussed the solutions together to arrive at the best answer. They had arranged how long they would work independently, how long they would work together, and who was to write the final report.

The students not only asked their friends but also criticised their own work, like what was revealed by Revi in the group discussion in Week 6. Revi was not satisfied with her answer on a determinant problem; she had used many more steps to reach the result. Revi said, “Why has my answer so many steps, while your answer is so simple? How do you do that Vera?” Vera gave her response, “Let me see. I combined the expansion of cofactor and row reduction”. Revi’s response, “I see, I only used row reduction.”

This experience encouraged them to be involved in discussions to evaluate and compare the differences of their methods. They realized that there were several ways to solve the problem. This teaching and learning strategy had enabled them to compare and discuss alternative strategies to solve the problems.

So, the use of the ACE teaching cycle in the Elementary Linear Algebra course had enabled students to discuss the solving of the mathematics problems. Through the discussions they had the opportunity to share knowledge and strategies on how to solve the problems so that their ability to solve the mathematics problems
improved. In the conventional classroom that I taught before, students did not have much opportunity to share knowledge and strategies in their effort to solve the mathematics problems in the classroom.

4.3.3 Students’ Ability in Communication

The aim of this section was to investigate students’ communication ability in mathematics lessons as consequence of the use of the ACE teaching cycle in Elementary Linear Algebra course. The analysis to ascertain students’ ability in communication will be presented based on the data from classroom observations of two students’ activities in the classroom, group discussions and concept maps presentations.

Group Discussions

In this part, students’ ability in communication will be evaluated based on their group discussion activities. For analysis purposes, the researcher used the data from the Group B discussions during Week 2. The topics that they discussed were about the Linear Equations System, so in their communication they used several mathematical terms. The discussion activities encouraged them to talk about mathematics in their group or in the classroom. In discussions, they had the opportunity to express opinions and to ask questions that helped them to answer the mathematics problem.

While discussing to solve of the problems, students were also involved in constructive conversation to find their solution. Next is the example of their talk to find the answer to the following linear equations system problem: From the linear equations system, x+2y-3z = 4, 3x-y+5z = 2, 4x+y+(a^2-14)z = a+2, for which value of a will the linear equations system have no solution, exactly one solution and an infinite number of solutions?

Revi expressed her idea to solve the problem:

We can solve it geometrically through drawing all their lines on a graph.
Salsa gave her response:

That way will not work Revi, there is an equation that contains one parameter, $a$.

While Revi was trying to construct the lines on the graph she gave her response:

Yes, it’s hard. I have also tried through the elimination and substitution method, it’s still hard. What should we do next?”

Asdi gave his suggestion:

Through elimination and substitution is hard for us to see the solution, I think we can try to make the system become simple first”

Salsa’s response:

How can we do that Asdi?

Asdi revealed his idea:

Let’s try; we use its augmented matrix and then we use elementary row operations to make the matrix in reduced row-echelon form.

Each of them was trying to find the reduced row-echelon form of the augmented matrix. Revi found it first:

I finished and found it Asdi, what next? I have no idea.

Asdi’s response:

Let me see, yes we have the same form of matrix. Next, let’s make the linear equations system based on this result.

Revi’s response:

O yes Andi, it became the simple system. How can we find the solution?
Asdi’s response:

Yes, from the reduced row-echelon form of the augmented matrix we find the answer. Let’s see if \( a = 4 \) we will have only 2 equations with 3 variables, that means that the system has infinitely many solution.

Salsa gave her response:

That makes sense Asdi, if \( a = -4 \) the system that we got from the reduced row-echelon form of the augmented matrix became inconsistent, so the system will not have a solution.

Asdi’s response:

So, if \( a \) is not equal to 4 or -4 the system will have exactly one solution.

Salsa’s response:

Yes Asdi, it makes sense. Finally, we can solve the problem.

The communication that ensued in the discussion had led them to solve the problems. In the discussion above, students had the opportunity to express their ideas to their peers, to extend their mathematics knowledge by considering the thinking and strategies of others, and they also had the opportunity to discuss the mathematics concept. All this reflected their communication ability in mathematics. So, the use of the ACE teaching cycle approach in the Elementary Linear Algebra course has given the opportunity to students to improve their ability in communication. This was possible because the teaching approach facilitated them to do discussions in the classroom. So, they had occasion to talk to each other in a group in their effort to solve the mathematics problems. In a conventional teaching approach, students have limited opportunities to communicate with each other.
Concept Maps Presentation

In this part, students’ ability in communication will also be evaluated using concept maps presentations. For analysis purposes, the researcher used the data from the concept maps presentation of Group F1 in Weeks 14. The mathematics topic that was presented by Group F1 in this concept maps presentation was about Linear Transformations.

The members of Group F1 have displayed their ability in mathematical communication through presenting the concept maps. Their communication ability was evident by their ability to construct the concept maps that contained links between mathematics ideas as seen in Figure 4.8 below, their ability to present the mathematics concept maps in front of the class, and their ability to discuss the concept maps in the class with their friends.

![Figure 4.8: Concept Map about the topic of Linear Transformation that was presented by Group F1 in the classroom.](image)

Students’ communication ability in this concept maps presentation was shown not only by the members of the presenting group but also by other students in the class. After the presentation, some students gave suggestions to the presenters. One of the students’ suggestions was like what revealed by Roza, "The concept map that was presented was very clear for me, but I see there was concepts that need to..."
be corrected, you wrote the mapping $T: V \rightarrow W$ in term of identity transformation, I thinks you should write the identity transformation on the mapping $T: V \rightarrow V$. The transformation must be on the same vector space.” Roza had paid careful attention to the concept map presentation so that they could give their ideas for improvement. She had the courage to communicate her idea in the classroom to others. In this respect, Roza have shown her ability in communication. As an activity of the ACE teaching cycle approach in the classroom, the concept maps presentation has given opportunity for students to communicate their mathematics ideas in the classroom.

The two sections above have explained the effects of the use of the ACE teaching cycle approach on students’ engagement and students’ learning in the Elementary Linear Algebra course at Padang State University in Indonesia. In relation to the use of the ACE teaching cycle approach, this study has focused on students’ engagement and students’ learning mathematics. Three other studies that have also used the ACE teaching cycle approach in their teaching and learning process had focused on students’ achievement in mathematics (Arnawa, 2006; Asiala, Cottrill, et al., 1997; Trigueros et al., 2007). Although the focus of this study is not the same as the three previous studies, it can be said that this study produced the same results as the previous studies i.e., they identified means for improving the quality of learning mathematics.

4.4 The Possibilities and Limitations of the Use of the ACE Teaching Cycle in the Elementary Linear Algebra Course

In this study, my position was as a lecturer and as a researcher. As a lecturer, I had responsibility to manage the Elementary linear Algebra course for a semester (January-June 2011). As a researcher, I was interested in evaluating the effects of the new approach (ACE teaching cycle) that I had used in my teaching practice on students’ engagement and students’ learning in mathematics. As a lecturer and researcher, my position was unique in that I had to reflect on what was happening in the class, to the students, and to me. Below are my reflections about my
teaching practice that I have implemented to reveal the possibilities and limitations of the use of the ACE teaching cycle in the Elementary Linear Algebra course.

In the ACE teaching cycle approach, students had to learn through three stages of activities: before class activities, in class activities, and after class activities. In before class activities, students were asked to learn the topics for a particular week individually and then to discuss in their groups to construct a concept map about the topics. In class activities, students were involved in a series of learning activities like concept map presentation, lecturer’s presentation, group discussions, and classroom discussions. In after class activities, students did two tasks (writing reflective journals and completing problem solving exercises).

At the beginning of the use of this approach, students displayed their doubts after receiving the lecturer’s explanation about the strategy of the teaching and learning process that would be implemented. The reasons for their doubts included the several activities that they had to do, the kinds of tasks that they had not experienced before like constructing concept maps and writing reflective journals, in addition to several other subjects that they also studied in the semester. Their doubts were reflected in Zola’s words, “Sir, this semester we take 8 subjects. The tasks that you will be giving to us are too much. How can we share the time with the other subjects?” Their doubts were reasonable because the approach was something new for them. I said to them that the time allocation for this course is not different from that of the other courses. In the Mathematics Department of Padang State University, for the course with three credits weightage the allocation of time to learn in the classroom is 150 minutes per week and to complete homework outside the classroom is 300 minutes per week (Penyusun, 2005). The ACE teaching cycle approach was designed to be implemented for this time allocation.

Based on experience years, the students had a lot of experience through the conventional teaching and learning style where the lecturer was the most active
person in the class and they did not have much work to do outside the classroom. After the use of the ACE teaching cycle for one semester, they revealed in the focus groups that they felt comfortable with the teaching and learning process using the ACE approach. I observed that all students were involved actively in all activities both inside and outside the classroom. They were active in constructing their understandings so that they were able to develop concept maps, they were active in discussions in the classroom, and they were also active in reflecting about what they had learnt.

In this ACE teaching approach, students did a series of activities in their learning process like, construction of concept maps, presenting and discussing the concept maps, discussing mathematics problems solving, writing reflective journals and completing exercises. I will use these activities as a structure of this section to reveal possibilities and limitations of the ACE approach.

4.4.1 Students’ Activities that Relate to Concept Maps

Students completed the task of developing the concept maps for the topics that would be discussed in the subsequent class. This task was completed by students in their small groups (two or three members). The concept maps that they produced were submitted at the next class meeting and then one of the groups presented the concept map to the whole class.

At the beginning, they experienced difficulty in completing this task. The reason for their difficulty was because they had no previous experience in completing a similar task or they did not possess sufficient knowledge about how to construct concept maps. They were previously given explanation about concept maps for only about 30 minutes during the first week of this course. However, their ability to construct a concept map continuously increased from one concept map to the next that they produced. They learnt from their experiences of developing making concept maps and as a result of the concept maps discussions in class.
Now, I realize that the 30-minute explanation is woefully inadequate to provide sufficient knowledge for students to be able to construct concept maps well from the beginning. I realised that this is one of the weaknesses of my teaching practice. If they were given sufficient information from the beginning, their ability to construct concept maps would have been better. So, I recommend providing sufficient time to equip students with the knowledge of concept maps before implementing the ACE teaching cycle.

The concept maps activity has encouraged students to learn before the materials were discussed in the class. The knowledge that they had acquired helped them to be actively involved in the class, they could make their contributions in discussions and they were active in asking questions to their friends and the lecturer. This state of affairs was very different with the conventional classroom that I had taught previously, where I spoke actively and students remained mostly silent.

The main textbook for the course was Elementary Linear Algebra (Indonesian translation version) that was written by Howard Anton. In the process of developing the concept maps, most of the students only used that textbook. They revealed that to be able to understand the materials in the book they had to read it until several times, as it was difficult for them to understand the new terms in the book. However, there were some students who tried to find other books as additional reference. They revealed that with using other sources they were able to understand the material better. At times, there were some aspects in the main textbook that were difficult to understand. However, in other books there were simpler explanations about these difficult aspects. In this course, I didn’t give them information about additional books that they could use to support their learning. For my future teaching practice, I will inform them about other sources that they could use to support their learning.

Concept maps presentation was the opening session of the learning activities in the classroom. Every week, a group was given the opportunity to present the
concept maps followed by a class discussion. The session took about 15 to 20 minutes at the beginning of the class. Along the semester, 12 small groups (with 2 or 3 members in each group) had the opportunity to present their concept maps in front of the class.

The preparation that was done by students to present the concept maps showed increasing quality from week to week. At the presentation in Week 2, the presenting group had not prepared any media to support their presentation because the group was informed at short notice. They just drew the concept maps on the blackboard using chalk, and then they explained it. Writing the concept maps on the board needed much time and this was a problem because the time allocation was limited. The next presenting group was informed one week before they were to make their presentation to give them the opportunity to develop a better concept map. In Week 3, the presenters used power point software but there were no concept maps in the presentation. They merely presented materials using the software. In Week 4, the presenters drew the concept maps on large-size paper and pasted it on the board. The limitation of this method was the writing on the paper that was not very clear to read for all students in the class. From Week 5 onwards, students constructed the concept maps using power point software. They could manage their presentation better than before. The students had learnt through their experiences to make a better preparation, so their presentation went well.

The concept maps presentations had triggered constructive discussions between students in the class. Through these discussions, the presenting group received useful inputs for improving their concept maps. For example, the following response was given in the Week 8 presentation, by a student who said, “The concept map is pretty good; it will be better if there is an explanation on the line that connects Vector Space and Subspace.” Another student gave a suggestion for correction of a misconception by stating, “On the explanation about the definition of linear combination in part $v = k_1v_1 + k_2v_2 + \ldots + k_nv_n$, the presenter said that $v_1$, $v_2$, $\ldots$, $v_n$ are vector components of $V$; I think they are not vector components, but
they are only vectors in vector space V.” The inputs that were usually given to the presenters included corrections of misconceptions and misplaced concepts on the map, and additional information that should be included on the concept map. Actually, the benefits of all the inputs were not only for the presenters but also for all students in the class.

All the students in the class were prospective teachers. The opportunity to stand in front of the class and to explain the materials was a valuable thing for them. Through these presentations they have practiced to deliver the materials systematically using concept maps. All of the experiences and knowledge that they acquired through this process was a valuable experience to prepare them to become teachers in the future. In the early weeks of course (Weeks 2, 3, and 4), the concept maps presentation and discussions took longer time (above 20 minutes) than expected. This was because the presenters did not prepare their concept maps sufficiently well. They lost much time to write or to stick the maps on the board. From Week 5 onwards, they constructed better concept maps. They developed the concept maps using Microsoft Power-point and prepared their concept maps to be presented using a LCD projector. As a result of the better preparations, the presentations were done efficiently so that the time that they needed for the concept maps presentation and discussion was about 12 minutes.

4.4.2 Presenting Materials by the Lecturer

In this teaching and learning Elementary Linear Algebra process using the ACE teaching cycle, I allocated 50 minutes out of 150 minutes to present materials. This was different from my previous teaching practices, where almost the entire allocated time was used to present materials by the lecturer. For using time efficiently, I designed material presentations using Microsoft Frontpage to be presented using a LCD projector. The structure of the presentation included a definition followed by its explanation, a theorem followed by its proof, and examples. This structure was not different from the structure of my previous
conventional presentation. The purpose of this presentation was to improve students understanding of the topics in the course.

Before I used the ACE teaching cycle as an approach for my teaching practice I was involved in the traditional way of teaching where the lecturer was the main actor in the class. Based on these two approaches, I had different experiences that were related to students’ responses to my presentation. In the traditional class, students’ responses were very minimal and they were reluctant to speak in the class. They would usually speak if the lecturer asked them questions or to give their opinion. The students’ response that I frequently found was when they asked to me to repeat my explanations. In the class using the ACE teaching cycle approach, I found increasing initiatives for the students to speak in the class. They spoke more critically about the proving of theorems and the difficulty to solve mathematics problems. This was possible because they had learnt before coming to class.

At the beginning of the use of the ACE teaching cycle, I tried to present all topics. Evidently, that was not effective because students had already learnt the materials first when they completed the concept maps task. Related to the students’ learning through the concept maps task, they had acquired numerous learning experiences. First, for preparing to construct the concept maps they had to learn about the topic individually using the textbook and other sources. Then, in developing the concept maps they discussed the topics in their groups. Next, they had the opportunity to learn the topics through the presentation of concept maps at the beginning of the class. So, through this series of learning experiences of the topics they acquired information and experience about the topics. For the next teaching practice using the ACE teaching cycle, the lecturer does not have to present all the topics. The lecturer could select the topics that would enable students to deepen their understanding by for example, presenting another way to prove the theorems and give examples that involve the use of complex concepts and procedures. Besides that, the lecturer could also save time that could be used for other activities in the class.
4.4.3 Classroom Discussion Activity

Discussions in class were divided into two sessions, group discussions and class discussions. In groups, students discussed the solving of mathematics problems that were selected by the lecturer. They discussed in groups for between 40 and 60 minutes during each class meeting. Soon after the group discussions ended, they engaged in classroom discussions for between 10 and 20 minutes to discuss the problems that arose from the group discussions.

Related to the use of the time for the discussion activity for both group discussions and classroom discussions, as a lecturer-researcher I realised that the time that I had allocated was not enough for them to solve the problems that they faced. During group discussions, when I informed them that the time was over some of them always revealed that they had not completed discussing and asked for more time. During classroom discussions, the time allocation that was available was too limited to discuss all problems that arose from the groups. Sometimes, there were three or four problems that emerged but only one or two of them could be discussed. For future learning using this ACE teaching cycle approach, I will add a little more time for these discussion activities. To increase the time for discussions, one possible way is to reduce the time allocation for the lecturer to explain the topics. I think, the time for explaining the topics by the lecturer could be reduced from 50 minutes to 30 minutes.

In group discussions, each group comprised four, five, or six members. Their membership did not change during the semester; all of them worked with the same friends throughout the semester. Learning together with the same friends in a group throughout the semester has advantages and disadvantages. One of the advantages was that all members in a group became closely known to each other so that this gave them the possibility of working more productively. Related to this, Eki revealed in a focus group, “The members of our group are constant along this semester. We got the benefit from this because we knew each other well. So, the group became more organized and the discussions can run more effectively.”
One of the disadvantages of the constant member of group members throughout the semester was that they did not have enough opportunity to be close with other friends in the class. For the next practice using the ACE teaching cycle approach I might consider not having constant membership of the groups throughout the semester.

From my observations on group discussions for one semester, I can say that the discussion groups have encouraged students to actively communicate their mathematics ideas with each other. From week to week, I saw them become more courageous to ask questions or to put forward ideas. In the early weeks of group discussion activities, they looked shy and reserved and not all members of the group were actively involved in the discussions. Perhaps the reason for this was that they still required time to adapt to the new learning environment. Gradually, I saw them become more courageous and almost all members of the groups were actively involved in discussions.

Class discussions also encouraged students to share their knowledge. Most of the groups could not solve all mathematics problems easily. They still had the opportunity to understand the problems that they faced during classroom discussions; a group that was not able to solve certain problems as able to get help from other capable groups. To resolve a problem that was raised by a group, a representative of the capable group was asked to explain their ideas in front of the classroom. In this way all students in the class who had the same problem received help.

The weakness encountered in these discussions was the cramped condition of the classrooms, so the distance between the groups was too close. The classroom became noisy when the group discussions began. Certainly, the noise had an impact on the level of students’ concentration in the discussions. To improve my next teaching practice using this approach classroom space should be a concern so that the discussions could be conducted well.
4.4.4 Reflective Journals and Exercises

Reflective journals and exercises were the last of a series of activities in the ACE teaching cycle that were completed by students. They wrote reflective journals individually and completed exercises in small groups (same as their concept map groups). For writing reflective journals, students were asked to write at least two pages of folio-sized paper about what they had learnt during the week. They were free to write whatever they wanted. They could write definitions and their explanations, theorems and their proofs, examples, etc. For exercises, lecturer gave students some mathematics problems to solve at home. The problems related to the topics that had been learnt. The purpose of these two activities was to improve their understanding of the materials that they had learnt.

Regarding reflective journals, at the beginning students faced difficulty in writing their reflective journals because they had never done such a task before. However, I saw their seriousness in doing the task. All students submitted all of their reflective journals throughout the semester, although there were some students who were late in submitting them. The quality of their reflective journal writing was getting better; at first they only contained the main parts of the materials like the definitions and theorems. As the journals improved, they added the opening and closing sessions and provided more detailed explanations. The reflective journal writing has facilitated students to explore what they had learnt. Their reflections allowed them to know which parts they already understood and which parts were difficult for them to understand.

At the end of the lecture, a student showed a compilation of reflective journals that she had produced during the semester. It was a complete record of the lectures that she had followed, even though I did not required students to compile all the reflective journals that they had written. What the student showed to me was a positive outcome. For my future teaching practice, I would suggest to all students to compile their reflective journals so that they will have a complete record of their experience in the learning process.
However, based on the reflective journals that were written by students, I had the impression that what they wrote was like a repetition of the presentation of topics that they had learnt. Their reflective journals did not provide a critical analysis of the topics and their learning experiences. Perhaps the cause of this was the lack of guidance that was given to them in writing a reflective journal. For my future teaching practice, I will equip students with the proper knowledge of reflective journal writing. Besides that, the instruction or guidance that is given to students must enable them to be able to do reflections critically.

Doing mathematics exercises for homework is a familiar thing for students. Almost all lecturers at the Mathematics Department of Padang State University give homework to their students. It is intended to provide practice opportunities for students to apply the knowledge they have acquired. Through the exercise activity in this ACE teaching cycle approach, students had the opportunity to improve their understanding of the topics that they had learnt. In this study, students did the homework in their groups. Doing these mathematics exercises in groups had advantages and disadvantages. The advantage was that the activity could foster cooperation and exchange of knowledge in solving problems. The disadvantage was that they became bound to the group to practice; a student with weak motivation would wait for her or his friends’ answer to complete the homework. Working in groups to complete homework also reduced the level of their freedom in learning and practicing, their work become dependent on group necessity. In fact, personally they may have different needs. For my future teaching practice, students working individually when completing homework exercises may be made optional.

4.5 Summary of the Chapter

This chapter presented qualitative and quantitative results of this study and provided the responses to the three research questions of the study. In response to research question 1 that was related to the students’ engagement in learning, the use of the ACE teaching cycle approach in the Elementary Linear Algebra course has enabled students to improve their engagement in learning. In response to
research question 2 that related to students’ learning, it was revealed that the implementation of the ACE teaching cycle affected students’ learning. The approach has given students opportunity to develop their learning activities that related to the concepts and procedures understanding, problem solving ability, and communication ability. Besides that, this chapter also contains the response to research question 3 that related to the possibilities and limitations of the implementation of the ACE teaching cycle approach in the Elementary Linear Algebra course. The possibilities and limitations were evaluated for each activity of the approach like, students’ activities that relate to the concept maps, presenting materials by the lecturer, classroom discussion activity, and reflective journal writing and completing exercises activity.
CHAPTER 5
CONCLUSION

5.1 Introduction

The previous chapter presented the results of this study. The aims of the present chapter are: (1) to reflect on the research results and how they answer each of the three research questions, (2) to discuss the implications of the study, (3) to describe the limitations of the research and (4) to provide recommendations for further research.

This chapter consists of eight sections. Section 5.2 discusses background and aims of the study. This section discusses the importance of conducting this research and the main outcomes of this study. Section 5.3 the major findings of the study. This section will highlight the findings of this research in relation to each of the three research questions that were proposed in Chapter 1. Section 5.4 discusses the implications of the study for the practice of teaching mathematics at college. Section 5.5 considers several limitations of the study, while Section 5.6 provides suggestions for further research. Finally, Section 5.7 provides a summary of the chapter.

5.2 Background and Aims of the Study

Teacher training college is the place where pre-service teachers can acquire knowledge and skills so that they can enter the working world. The knowledge and skills that are learnt by students must be relevant to the needs of their careers. The knowledge and skills that are learnt by a prospective mathematics teacher are not only the content knowledge and skills about mathematics but also the pedagogical content knowledge so that they can be proficient mathematics teachers (Livy & Vale, 2011). According to Schulman (1998) pedagogical content knowledge is a kind of knowledge that relates to the ways teachers represent and
formulate their knowledge when teaching. Mathematical knowledge and pedagogical knowledge are two important dimensions that proficient mathematics teachers require (Livy & Vale, 2011; Ma, 1999).

When equipping students with mathematical knowledge at college, the problem that often arises according to Taplin (1998) is that most students enter college with inadequate mathematics skills, thus causing them to experience difficulty in understanding mathematics concepts because most concepts in mathematics relate to abstract ideas that are related to each other. Students will face difficulties in studying mathematics if they lose the link between concepts. According Brijlall & Maharaj (2009), many students perform poorly in mathematics because they are unable to adequately handle information given in symbolic form that represents objects, for example mathematical expressions, equations and functions. Besides this problem, according to Maharaj (2011) a high percentage of students have only a static view about mathematics; students with such a view will experience difficulties to learn mathematics in depth and will find it difficult to engage in the teaching and learning process. So, these are problems that are related to students’ mathematics learning and their engagement in the classroom.

Another problem of teaching mathematics to prospective mathematics teachers is that the teaching and learning process is still run conventionally in a teacher-centred approach in several teachers’ colleges. This teacher-centred teaching and learning process does not give the optimal conditions for students to develop into proficient teachers. In the teacher-centred approach classroom, students’ dependence to acquire knowledge and skills from the lecturer is very high and students’ opportunity to interact and socialize with each other is very limited. The prospective teachers must have the opportunity to develop their ability to become independent learners. This ability to be independent learners will help them to develop in their careers as teachers. In college, students must also be given the opportunity to develop their ability in socializing, discussing, and sharing ideas between them because these activities will support their careers in the future (Dikici, 2006; Pedro & Brunheira, 2001).
The conventional teaching model needs to be changed in order to improve both the quality of the teaching practice and student learning of mathematics. The focus of the teaching and learning process must be the students (student-centred learning). To accommodate this, one approach that can be adopted by the lecturer is informed by constructivism. This theory suggests that, to the extent that individuals’ understandings are built from their unique web of prior concepts and their current subjective experience, teachers or lecturers cannot transfer their knowledge into their students’ minds. The learner must actively engage in problem solving situations in order to build understandings that are an extension of, and later become an integral part of, his or her cognitive web (Schifter & Simon, 1992).

One of the teaching models that can be used to implement the instructional treatments based on constructivism is called the ACE (Activity, Classroom Discussion, Exercises) teaching cycle (Dubinsky, 2001). This model was first introduced by Dubinsky (1995) to help students learn mathematics through the three steps of the learning process namely, activities before class, classroom discussions, and exercises as a homework activity after class. The description of the three components of the model is as follows: (1) Activity: I used concept maps as a students’ activity before class. Students worked together in small groups (two or three members) to construct concept maps. The main focus of this activity is to encourage students to explore their previous knowledge and to learn new mathematics concepts. (2) Classroom discussions: students used the cooperative group learning strategy. Students were grouped into permanent teams comprising of four, five, or six members each. In the groups, they discussed solving of mathematics problems. This strategy provides a social context in which the students can work together to solve mathematics problems. (3) Exercises: students were given homework to be completed outside of class. There were two kinds of homework that they had to complete; traditional exercises and reflective journals. In this study, students completed traditional exercises in small groups (same groups as when they developed the concept maps), while to write the reflective
journals students worked independently. The use of the ACE teaching cycle is expected to improve students’ engagement and to facilitate students to develop their learning.

The main purpose of this study was to develop, implement, and evaluate the use of the Activity, Classroom discussion, and Exercise (ACE) teaching cycle in an Elementary Linear Algebra course, and in particular to (1) investigate the effects of implementation of the ACE teaching cycle in the Elementary Linear Algebra course on students’ engagement, (2) investigate the effects of implementation of the ACE teaching cycle in the Elementary Linear Algebra course on students’ learning, and (3) investigate the possibilities and the limitations of the implementation of the ACE teaching cycle in the Elementary Linear Algebra course.

5.3 The Major Findings of the Study

The major findings of this research are presented based on the three research questions that were originally proposed.

**Research question 1:**

*What are the effects of the implementation of the ACE teaching cycle in the Elementary Linear Algebra course at Padang State University on students’ engagement?*

In this study, the degree of student engagement in the classroom was assessed through three domains namely, cognitive engagement, affective engagement, and behavioural engagement (Caulfield, 2010; Chapman, 2003).

Cognitive engagement is closely related to academic involvement or approaches to learning involving the idea of investment, recognition of the value of learning and a willingness to go beyond the minimum requirement (Attard, 2011; Fredricks et al., 2004). The three approaches to learning namely, surface strategy (closely associated with lower levels of learning outcomes – memorisation, practising, handling tests), deep strategy (closely related to higher levels of learning outcomes – understanding the question, summarising what is learnt, connecting
knowledge with the old ways of learning), and reliance (relying on teachers) (Biggs, 1978; Kong et al., 2003).

Behavioural engagement is closely related to student participation in the classroom. Active participation in the classroom is demonstrated by, compliance with classroom procedure, taking initiative in the group and classroom, becoming involved in the classroom activities, asking questions, regularly attending class, and comprehensively completing assignments (Chapman, 2003; Skinner & Belmont, 1993).

Affective engagement is closely related to students’ reactions to the learning environment (school, teachers, peers, and academic curriculum) that influence willingness to become involved in school activities (Attard, 2011; Chapman, 2003). According to Miserandino (1996) and Kong et al. (2003) students’ affective engagement can be seen through four dimensions namely, interest, achievement orientation, anxiety, and frustration.

To answer the research question above, the researcher used the information from qualitative data that were obtained from focus group interviews and classroom observations as well as from quantitative data obtained through administration of the closed questionnaire. The results based on data from these sources showed that the use of the ACE teaching cycle in the Elementary Linear Algebra course at Padang State University gave the change on students’ engagement in learning as was expected. Specifically, the effects of the approach will be presented based on each aspect of the cognitive, affective, and behavioural engagement.

The effects of the use of the ACE teaching cycle on the surface strategy aspect of students’ cognitive engagement

Surface strategy is the strategy that relates to lower levels of learning that were used by students in their learning process like memorisation. The frequency in the use of this strategy decreased slightly as a consequence of the implementation the ACE teaching cycle in their learning process. This finding was confirmed by
analysis of the questionnaire data, when the mean value of 2.92 of the surface strategy aspect on the post-test was slightly lower than that on the pre-test mean value of 2.98. This result was consistent with what I had expected i.e., there was a decline in students’ activity in using the surface strategy in the mathematics learning process. The use of the ACE teaching cycle has encouraged students to be involved in a series of learning activities on a mathematics topic. This gave students more opportunities to learn more widely and deeply so that it resulted in a decrease in the frequency of surface strategy that was used by students.

However, some students still considered that surface strategy is a strategy that is useful in some situations of their learning process. Through using this strategy, they tried to grasp the topics being studied despite the fact that such topics were difficult for them to understand. By trying to understand these topics using surface strategy enabled them to be able to follow the lessons because in mathematics the concepts are related each other.

*The effects of the use ACE teaching cycle on the deep strategy aspect of students’ cognitive engagement*

Deep strategy is closely related to higher levels of learning outcomes like summarising what is learnt, applying knowledge, connecting knowledge with the old ways of learning, etc. The result of the analysis on this deep strategy aspect was based on the data that came from focus groups, classroom observations, and the closed questionnaire.

Focus group interviews revealed that the ACE teaching cycle had enabled students to study conscientiously through a series of learning activities like creating of concept maps, discussing of problem solving, doing exercises, and writing of reflective journals. The concept maps activity has encouraged students to understand the materials well and provided more time to learn before class. Problem solving discussions and doing exercises have enabled students to apply knowledge, to share knowledge, and to strengthen their understanding. Reflective journal writing encouraged students to review and to summarize the materials and
to enable them to ascertain the parts that they had understood and the parts that were difficult.

Students’ response on the questionnaire also showed that the use of the ACE teaching cycle had a positive effect on the deep strategy aspect of students’ cognitive engagement. This finding was evident from the mean value of students’ responses in the pre-test and post-test. The mean value of the deep strategy aspect in the post-test (3.50) was higher than that in the pre-test (3.39). This finding was probably because the ACE teaching cycle approach gave the opportunity to students to think about what they had already learnt through the writing of the reflective journals, completion of homework exercises, to learn using the textbook in their preparation to construct concept maps, to explore the materials through discussions, and to do exercises inside and outside the classroom.

So, analysis of both qualitative and quantitative data showed that the use of the ACE teaching cycle in the Elementary Linear Algebra course had the same effect on the students’ deep strategy of cognitive engagement to that which the researcher had expected. Through the use of the ACE teaching cycle in the Elementary Linear Algebra course students had opportunities in applying their knowledge, sharing knowledge, summarising what was learnt and using more time in learning. The use of this approach allowed them to achieve deep understanding of the materials, because this approach encouraged them to learn conscientiously.

*The effects of the use of the ACE teaching cycle on the reliance aspect of students’ cognitive engagement*

The results of the analysis of data from focus group interviews and classroom observations revealed that the use of the ACE teaching cycle in the Elementary Linear Algebra course had an effect on students’ way in learning. Students had the opportunity to learn not only from the lecturer but also from other resources like textbooks, concept maps, group discussions, reflective journals, and exercises. Students’ dependence on the lecturer’s explanation decreased. The strategy that
had been implemented facilitated them to improve their ability to study by themselves. They became more independent in their learning.

However, students also displayed their reliance on the lecturer’s direction. The lecturer’s direction was important for them to start learning, to give him guidance on what should they do, and to encourage them to learn by themselves; without the lecturer’s direction they would not be compelled to construct concept maps, to discuss in groups, to write reflective journals, and to do exercises.

Students’ responses on the questionnaire also showed that the use of the ACE teaching cycle gave the change on the reliance aspect of students’ cognitive engagement as expected. This fact can be seen through the mean values of students’ responses in the pre-test and the post-test. The mean value of the reliance aspect in the post-test (3.78) was higher than that in the pre-test (3.70). All items of the reliance aspect of cognitive engagement relate to students’ trust in the lecturer. These items were not specifically to reveal students’ independence in learning. Based on the students’ responses to the questionnaire, as consequence of the use of the ACE teaching cycle students were more likely to follow the direction and examples that were given by the lecturer. This finding could have been due to the ACE teaching cycle approach requiring the lecturer to give instructions to learn individually, to create concept maps, to discuss the mathematics problem solving, to do exercises, and to write reflective journals. All of these instructions had effect on how the students learn.

The effects of the use of the ACE teaching cycle on the interest aspect of students’ affective engagement

The results of the analysis of the qualitative data showed that students had interest in learning mathematics using the ACE teaching approach. This finding may have been caused by the approach enabling them to learn in a variety of ways that made them look forward to attend class. As consequence of their interest they felt that learning mathematics was an enjoyable activity and encourage them to be gainfully involved in learning.
The quantitative data from the questionnaire also showed improvement in the mean value of the interest aspect of affective engagement. The overall mean value of the items in the post-test was 4.17 while it was 4.02 in the pre-test. This finding suggests that the implementation of the ACE teaching cycle in the Elementary Linear Algebra course resulted in producing a positive effect on students’ interest in learning mathematics. The use of the ACE teaching cycle approach had positive impact on students’ readiness to learn new topics. They were happy to learn a new topic. This finding is different from my previous experience as a lecturer, where most of the students felt worried about learning a new topic. The increase in the mean value of students’ responses may be the result of the approach having encouraged students’ to learn before the topic was discussed in the classroom.

*The effects of the use of the ACE teaching cycle on the achievement orientation aspect of students’ affective engagement*

The results of the analysis of focus group interviews data revealed that the ACE teaching cycle encouraged students to become more active in learning. When they faced difficulties in understanding the materials, they did not stop learning but they were still trying to understand them. Effort to understand the materials were by allocating more time for self-study out of the classroom so that they could learn the materials thoroughly. This finding showed that the approach had influenced students’ achievement orientation in learning.

Students’ responses to the questionnaire revealed that most of the students selected option 4 (often) or option 5 (almost always) in all items. This trend could be seen from the mean values for both pre-test and post-test (4.54 and 4.50). These mean values showed a slight decrease in students’ responses to the achievement orientation aspect of affective engagement. This result was not in accordance with the expectations of the researcher who expected an increase in this aspect, but based on both the average values it can be said that the students displayed good achievement orientation before and after the use of the ACE approach. As a researcher I observed that there was no significant change in the
achievement orientation aspect of affective engagement. In other words, the implementation of the ACE teaching cycle in the Elementary Linear Algebra course did not significantly affect students’ achievement orientation.

So, the qualitative data revealed that the change of students’ achievement orientation was as expected by the use of the ACE teaching cycle approach. Meanwhile, the quantitative data did not show an increase in the mean value from the pre-test to the post-test. However, the mean value was still high. This finding showed that students had high achievement orientation before and after the implementation of the ACE teaching cycle. I can say that the use of the approach still maintained students’ achievement orientation at a high level.

The effects of the use of the ACE teaching cycle on the anxiety aspect of students’ affective engagement

The qualitative data suggest that the use of the ACE teaching model did not trigger students felt anxious in mathematics learning. The approach facilitated student to felt happy and safe in learning. Related to the test, the qualitative and quantitative data suggest that students experienced anxiety in facing the test. From the quantitative data, the mean values of all items in the post-test (3.46) were lower than in the pre-test (3.49). There was a slightly decreased in the means of students’ responses in the post-test compared with their responses in the pre-test. This trend suggests that students’ level of anxiety that relate to test had slightly decreased.

According to Peker (2009) one of the causes of anxiety in learning mathematics is due to negative experiences in the learning process like failing a test, difficulty in understanding a concept, limited support from the lecturer, etc. So, this trend suggests that the implementation of the ACE teaching cycle in the Elementary Linear Algebra reduced the students’ negative experiences in learning mathematics. This finding was similar to that of the researcher’s expectations.
The effects of the use of the ACE teaching cycle on the frustration aspect of students’ affective engagement

In focus group interviews, some students revealed that the learning activities that they followed did not cause them to feel frustrated. This response suggests that students could follow the learning well and with enjoyment. Meanwhile, other students revealed that they felt frustrated only when they made mistakes in the test. This is common reaction because most of the students felt frustrated when they gave the wrong answer in the test.

The low levels of their frustration were also seen from the questionnaire. On both occasions when the questionnaire was administered the findings revealed that the mean value of the frustration aspect of affective engagement was less than 2. This finding suggests that the students responded with option 1 (almost never) or option 2 (seldom) from the five options that were available. This trend gave the indication that the levels of students’ frustration in learning mathematics were low before and during the use of the ACE teaching cycle. However, the overall mean value for all items decreased from 1.75 in the pre-test to 1.66 in the post-test. This finding suggests that the level of students’ frustration decreased as a result of the use of the approach.

The decrease in this mean value may be due to the students learning the new topics through a series of activities that they learnt step by step. First, they read the textbook in preparation for constructing the concept maps. Then, they constructed the concept maps about the topics. Next, they were involved in discussions in the classroom about the topics. Then, they listened to the lecturer’s explanations about the topics. Finally, they wrote reflective journals and completed homework exercises about the topics. So, they did not learn the new topics all at one time but gradually.

So, the qualitative and quantitative data suggest that students also felt frustrated in learning mathematics before and during the use of the ACE teaching cycle approach. The qualitative data revealed that the level of students’ frustration
during the use of the approach became lower. This finding suggest that the use of the ACE teaching cycle had influenced the students’ frustration in learning similar to what the researcher had expected.

*The effects of the use of the ACE teaching cycle on the attentiveness aspect of students’ behavioural engagement*

In the focus group interviews, students revealed that they were actively involved in the learning activities like doing all tasks and being active in discussions. They revealed that they benefited by learning with this approach, by sharing ideas in discussions, reviewing the materials, and acquiring deep understanding. They also planned the strategy in the discussions so that their discussions proceeded smoothly run well and they benefited fully through mutual exchange of information. This showed that they were seriously involved in the learning process. This finding suggests that the students engaged with the teaching and learning procedures that were implemented in the course.

The attentiveness aspect of behavioural engagement could also be seen through classroom observations. All groups in the class were involved in active discussions; they showed their seriousness in discussing to solve the mathematics problems those they faced. Through discussions in groups, they had the opportunity to share knowledge in their effort to solve the problems that they faced. This trend was also suggested that the use of the approach had affected their attentiveness in learning.

The data about this attentiveness aspect also came from the questionnaire. Students were required to respond to six items about the attentiveness aspect of students’ behavioural engagement. The mean value for the attentiveness aspect of students’ behavioural engagement was 3.79 in pre-test and 3.78 in the post-test; these values are almost same. Before the use of the ACE teaching cycle the level of students’ attentiveness in learning mathematics was high and after the use of the approach their attentive levels were still high. So, generally the researcher can
say that the use of the approach could main students’ attentiveness in learning at a relatively high level.

So, the results of the analysis of the data from the focus group interviews and classroom observations revealed that students were actively involved in the teaching and learning process using the ACE teaching cycle. They were active in constructing concept maps, discussing in the class, and doing the tasks like writing the reflective journals and solving mathematics problems. Their activities reflected their levels of attentiveness in learning. The quantitative data revealed that students’ the levels of attentiveness in learning were high before and after the use of the ACE teaching cycle as an approach in teaching and learning process. This finding suggests that the use of the ACE teaching cycle approach in the Elementary Linear course was able to maintain the students’ attentiveness in learning.

The effects of the use of the ACE teaching cycle on the diligence aspect of students’ behavioural engagement

As a lecturer and researcher in this study, my expectation was that the use of this approach in my teaching practice would have a positive effect on the students’ diligence in mathematics learning. The data for this aspect came from focus group interviews and the questionnaire.

In the focus group interviews, students revealed that the use of the ACE teaching cycle in the Elementary Linear Algebra had affected their way of learning; they were more diligent and allocated more time to study. They also revealed their persistence in learning and their willpower to understand the topics. The teaching approach had encouraged them to study hard so that they were able to understand the topics well and complete all their tasks.

The data about this diligence aspect also came from the questionnaire. The mean value of students’ responses to the diligence aspect of behavioural engagement improved from 3.79 in the pre-test to 3.94 in the post-test. This increase gave the
indication that the use of the ACE teaching cycle approach had affected students’ diligence in mathematics learning. This trend was possible because the approach had facilitated them to be involved in learning through various activities and gave them opportunities to be actively involved in the teaching and learning process. So, the use of the approach has influenced the diligence aspect of behavioural engagement in the same manner as what the researcher had expected.

Summary of the Cognitive Engagement, Affective Engagement, and Behavioural Engagement

The use of the ACE teaching cycle approach in the course of Elementary Linear Algebra at Padang State University for one semester has influenced the students’ engagement in learning. The influence could be seen from the qualitative and quantitative data on the three domains of students’ engagement in learning namely, cognitive, affective, and behavioural.

The qualitative data revealed the effects of the use of ACE teaching cycle approach on the three domains of cognitive engagement. Regarding cognitive engagement, students showed their engagement through three aspects: surface strategy, deep strategy, and reliance. The data revealed that the students used both surface strategy and deep strategy in their efforts to engage in the teaching and learning process. The qualitative data also revealed that students became more independent in learning and their dependence to get knowledge from the lecturer decreased with time. Regarding affective engagement, students showed their engagement through four aspects: interest, achievement orientation, anxiety, and frustration. The qualitative data revealed that the use of the ACE teaching cycle approach had impact on students’ engagement in learning where the students were more interested in learning, students were encouraged to study hard to achieve their goals, students felt anxious in learning associated to their desire to succeed, and the level of students’ frustration tended to diminish. As for behavioural engagement, students showed their engagement through two aspects: attentiveness and diligence. The data on these aspects revealed that the use of the approach had impact on students’ engagement where students showed their active involvement
in the teaching and learning process and they also showed their diligence in
learning.

The quantitative data that were obtained from the Student Engagement in the
Mathematics Classroom questionnaire also showed the effects of the use of the
ACE teaching cycle approach in the Elementary Linear Algebra course. Students
responded to the questionnaire on two occasions, before and after the use of the
approach in their learning process. Table 5.1 below presents the mean values of
all aspects of engagement in the pre-test and in the post-test.

Table 5.1: Mean Values and Standard Deviations of the Aspects of Engagement
in the Pre-Test and the Post-Test (n = 37)

<table>
<thead>
<tr>
<th>Aspects of Engagement</th>
<th>Pre-test</th>
<th>Post-test</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Standard</td>
<td>Mean</td>
<td>Standard</td>
</tr>
<tr>
<td></td>
<td>deviation</td>
<td>deviation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cognitive Engagement:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface Strategy</td>
<td>2.98</td>
<td>1.02</td>
<td>2.92</td>
<td>0.89</td>
</tr>
<tr>
<td>Deep Strategy</td>
<td>3.39</td>
<td>0.88</td>
<td>3.50</td>
<td>0.78</td>
</tr>
<tr>
<td>Reliance</td>
<td>3.70</td>
<td>0.67</td>
<td>3.78</td>
<td>0.68</td>
</tr>
<tr>
<td>Affective Engagement:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interest</td>
<td>4.02</td>
<td>0.76</td>
<td>4.17</td>
<td>0.69</td>
</tr>
<tr>
<td>Achievement Orientation</td>
<td>4.54</td>
<td>0.63</td>
<td>4.50</td>
<td>0.59</td>
</tr>
<tr>
<td>Anxiety</td>
<td>3.49</td>
<td>0.86</td>
<td>3.46</td>
<td>0.85</td>
</tr>
<tr>
<td>Frustration</td>
<td>1.75</td>
<td>0.76</td>
<td>1.66</td>
<td>0.74</td>
</tr>
<tr>
<td>Behavioural Engagement:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attentiveness</td>
<td>3.79</td>
<td>0.83</td>
<td>3.78</td>
<td>0.81</td>
</tr>
<tr>
<td>Diligence</td>
<td>3.79</td>
<td>0.84</td>
<td>3.94</td>
<td>0.75</td>
</tr>
</tbody>
</table>

On the aspect of surface strategy, deep strategy, reliance, interest, achievement
orientation, attentiveness, and diligence the researcher expected that their mean
values would increase. However, not all of them showed an increase. There were
two aspects that showed a slight decrease in the mean value namely: achievement
orientation and attentiveness. While the mean values were high before and after
the use of the approach, the decrease in mean value of these two aspects was not too significant. The other five aspects showed an increase in the mean value.

On the aspects of anxiety and frustration, the researcher had expected that their mean values would decrease, as was demonstrated by students’ responses. So based on this quantitative data, the researcher can say that the use of the ACE teaching cycle approach in the Elementary Linear Algebra course has had an effect on students’ engagement in learning, with students becoming more engaged in their learning.

So, based on the qualitative and quantitative data the researcher can say that the implementation of the ACE teaching cycle approach in the Elementary Linear Algebra course has affected students’ engagement in learning. The approach has encouraged students to improve their engagement in learning.

The discussion above that relate to the research question 1 summarised the effects of the use of the ACE teaching cycle approach on students’ engagement in the Elementary Linear Algebra course at Padang State University in Indonesia. Arnawa (2006) had also conducted research using ACE teaching cycle model in his teaching practice at Andalas University in Indonesia. One of the focuses of his study was about students’ attitudes towards teaching and learning process. The result of his study was students who attended the class using the ACE teaching cycle approach had more positive attitudes towards the teaching and learning process of abstract algebra than students who attended the traditional class. Although the focus of this study is not the same as the Arnawa’s study, it can be said that this study produced the same results as the previous study i.e., they identified means for improving the quality of learning mathematics.
Research question 2:

What are the effects of the implementation of the ACE teaching cycle in the Elementary Linear Algebra course at Padang State University on students’ learning?”

The answer to this research question relate to students’ understanding of concepts and procedures, students’ abilities in problem solving, and students’ abilities in communication and are presented below. These abilities of students were evaluated through classroom observations, focus group interview, students’ reflective journals, and students’ concept maps.

The effects of the use of the ACE teaching cycle in the Elementary Linear Algebra course at Padang State University on students’ understanding of concepts and procedures

The data for students’ understanding of concepts and procedures were obtained from classroom observations, students’ reflective journals, and concept maps.

During classroom observations I observed that at the beginning of the discussion to solve the problems students had different views about the mathematics topics. Some of them did not as yet have a good understanding about the important concepts and procedures, while others were able to understand the concepts and procedures in the materials. This finding was evident from their conversations in the groups. Their conversations in group discussions revealed that students helped each other to understand the topics. So, the implementation of the ACE teaching cycle in the Elementary Linear Algebra course had facilitated students to increase their understanding of concepts and procedures. Using the ACE approach they had the opportunity to learn not only from the lecturer but also from their friends. In this approach, they had flexibility in posing questions to their friends; they usually asked questions immediately when they faced a problem as was observed in the group discussions. The conversation among students in the discussions facilitated them to improve their understanding of concepts and procedures in mathematics.
Regarding the students’ reflective journals, students were asked to write about what they had learnt during one week of instruction; this activity was assigned as homework for them. The use of this reflective journal in this part is to describe students’ knowledge that relate to their performance in understanding the mathematics concepts and procedures. In their reflective journals, students tried to present the mathematics contents that they have learnt. They presented the definitions, axioms, theorems, examples, and explanations that they had learnt. The definitions, theorems, and axioms that were presented in the reflective journals were similar with the definitions, theorems, and axioms in the textbook. There was the impression that they had just copied the terms into their reflective journals. In actual fact, in mathematics is not easy to write mathematics terms using other symbols or other words as the meanings could have changed.

Through the reflective journals, students have shown their efforts in learning. They re-opened their textbook and tried to write by themselves the important things that they had learnt during the one week. This finding suggests that the reflective journal task has encouraged students to learn the mathematics concepts and procedures.

Hence, the writing of reflective journals has facilitated students to explore what they have learnt. To enable students to write the reflective journals students would have gone through a series of learning activities on the topics. First, students learnt the topics individually using the textbook. Then, they discussed in their small groups to construct concept maps about the topics. Then, they attended the class when they had the opportunity again to learn the topics through the presenting of the concept maps, lecturer’s presentation, and group discussions. Then, after class they completed homework exercise on the topics. Finally, they reflected on what they had learnt during the week. This would give them the opportunity to deepen their understanding of the topics.

Developing mathematics concept maps was one of the homework that had to be completed by students every week. They constructed the concept maps about the
topics that would be discussed in the classroom during the next lesson. These topics were something new for them, because the topics had not been discussed in their classroom before. To be able to construct the concept maps they had to learn the topics first so that they had knowledge about the topics. The concept maps that they submitted as homework were the result of their efforts outside the classroom.

At the beginning, the students experienced difficulty in completing the concept map task. This assignment was a new kind of homework for them. All students in the class had never been given a task like this before. So, some of the groups failed to submit their concept maps assignment on time. Their reason for this delay was that they felt confused about how to construct the concept maps. For the groups that submitted their assignment, most of the concept maps that they had developed were very simple; they just indicated the main topics and linked them with the lines.

The knowledge about concept maps and how to develop them was given by the lecturer at the beginning of the course. They learned about concept maps not only from the lecturer’s explanation and the group discussions but also through their own efforts to find the information. A student revealed that he obtained a lot of information about concept maps and the examples of mathematics concept maps through the internet. Their ability to create the concept maps increased from week to week. This result could be seen from their concept maps reports that were getting better.

Gradually, the concept maps that were produced by students improved from week to week. The increasing ability of students to construct the concept maps could also be seen by the way they constructed the concept maps. Some of them had constructed the concept maps using computer technology (power point software), while others drew them in their own handwriting. The concept maps that they produced reflected their efforts to understand the topics. So, as a lecturer-researcher I can say that the use of the ACE teaching cycle approach in the Elementary Linear Algebra course had an effect on the improvement of students’
learning. The concept maps task has encouraged students to learn and to improve their understanding of the mathematics concepts and procedures.

*The effects of the use of the ACE teaching cycle in the Elementary Linear Algebra course at Padang State University on students’ ability in problem solving*

In this study, students’ ability in mathematics problem solving was evaluated through the group discussions activity. The discussions involved solving the selected mathematics problems. Through the discussions, students had the opportunity to sharpen their ability in solving mathematics problems. During discussions, they were active in finding and sharing ideas to arrive at better answers to solve the mathematics problems. Sharing ideas helped them to understand the topics and to solve the problems.

In their effort to find the best solution in group discussions, students not only helped each other but were also able to critique their own work. This situation encouraged them to involve themselves in discussing to evaluate and compare the differences of their methods. They realized that there were many ways to solve the problem. This teaching and learning strategy had enabled them to compare and discuss alternative strategies to solve the problems.

So, the use of the ACE teaching cycle in the Elementary Linear Algebra course had facilitated students to discuss the solving of the mathematics problems. Through the discussions they had opportunity to share knowledge and discuss strategies on how to solve the problems so that their ability to solve the mathematics problems improved. In the conventional classroom that I taught before, students did not have much opportunity to share knowledge and discuss strategies in their effort to solve the mathematics problems in the classroom.

*The effects of the use of the ACE teaching cycle in the Elementary Linear Algebra course at Padang State University on students’ ability in communication*

The data for students’ ability in communication were obtained from classroom observations through two students’ activities in the classroom, group discussions and concept maps presentations.
In group discussion activities, students were encouraged to talk about mathematics in their group or in the classroom. In discussions, they had the opportunity to express opinions and to ask questions that led to answering the mathematics problem. In discussing to solve problems, students were also involved in constructive conversation to find the best answer. Communication that occurred in the discussion had enabled them to solve the problems. In the discussions, students had the opportunity to express their ideas to peers, to extend their mathematics knowledge by considering the thinking and strategies of others, and they also had the opportunity to discuss the mathematics concepts. All of this reflected their communication ability in mathematics. So, the use of the ACE teaching cycle approach in the Elementary Linear Algebra course has given the opportunity to students to improve their ability in communication. This was possible because the teaching approach facilitated them to be engaged in discussions in the classroom. So, they had occasion to talk each other in a group in their efforts to solve the mathematics problems. In the conventional teaching approach, students had limited opportunities to communicate with each other.

Using concept maps presentations, students’ communication ability could be seen; they were able to construct the concept maps that contained the links of mathematical ideas, they were able to present the mathematics concept maps in front of the class, and they were able to discuss the concept maps in the class with other friends. Students’ communication ability in this concept maps presentation was displayed not only by the members of the presenting group but also by other students in the class. As an activity of the ACE teaching cycle approach in the classroom, the concept maps presentation has given the opportunity for students to communicate their mathematics ideas in the classroom.

The use of the ACE teaching cycle in the Elementary Linear Algebra course had resulted in improvement of students’ ability in oral and written communication skills. This was possible because the teaching approach facilitated them to do discussions and write reflective journals. So, they had the opportunity to talk to each other in groups or in classroom discussions in their efforts to solve the
mathematics problems. They also had the opportunity to write and explore what they had learnt. In the conventional teaching approach, students had limited opportunities to communicate with each other.

The part above that relate to the research question 2 have explained the effects of the use of the ACE teaching cycle approach on students’ learning in the Elementary Linear Algebra course at Padang State University in Indonesia. Three other studies that have also used the ACE teaching cycle approach in their teaching and learning process had focused on students’ achievement in mathematics (Arnawa, 2006; Asiala, Cottrill, et al., 1997; Trigueros et al., 2007). Although the focus of this study is not the same as the three previous studies, it can be said that this study produced the same results as the previous studies i.e., they identified means for improving the quality of learning mathematics.

**Research question 3:**

*What are the possibilities and the limitations of the implementation of the ACE teaching cycle in the Elementary Linear Algebra course at Padang State University?*

Based on students’ experience before the use of the ACE teaching cycle, it was revealed in the focus group interviews that they acquired a lot of experience through the conventional teaching and learning style where the lecturer was the most active person in the class and they did not have to do much work outside the classroom. After the use of the ACE teaching cycle for one semester, students revealed that they felt comfortable with the teaching and learning process using the approach. I observed that all students were involved actively in all activities both inside and outside the classroom. They were active in constructing their understandings so that they were be able to create concept maps, active in discussions in the classroom, and were also active in reflecting about what they had learnt.

In this ACE teaching approach, students did a series of activities in their learning process like, construction of concept maps, presenting and discussing the concept
maps, discussing mathematics problems solving, writing reflective journals and completing exercises. I will use these activities as a structure of this section to reveal possibilities and limitations of the approach.

Students’ Activities that Relate to the Concept Maps

Students did the task of constructing the concept maps for the topics that would be discussed in the class. This task was completed by students in their small groups (of two or three members). The concept maps that they produced were submitted at the next class meeting and then one of the groups presented their concept map.

At the beginning, they experience difficulty to complete this task. The reason for their difficulty was that they had no previous experience to complete a similar task or they did not possess enough knowledge about how to create the concept map. They were given an explanation about concept maps for only about 30 minutes during the first week of this lecture. However, their ability to develop a concept map was constantly increasing from one concept map to the next that they produced. They learnt through their experiences of constructing concept maps and from concept maps discussions in class at each meeting.

Now, I realize that the 30-minute explanation is inadequate to provide sufficient knowledge for students to be able to construct concept maps well from the beginning. I assume that this is one of the weaknesses of my teaching practices. If they were given sufficient knowledge from the beginning, their ability to construct concept maps would have been better. So, I recommend providing sufficient time to equip them with the knowledge of concept maps before the use of the ACE teaching cycle.

The concept maps activity has encouraged students to learn before the materials were discussed in the class. The knowledge that they had acquired encouraged them to be actively involved in the class, they could give their contributions in discussions and they were active in asking questions to friends and the lecturer.
This state of affairs was very different with the conventional classroom that I taught before, where I spoke actively and students were mostly silent.

The main textbook for the course was Elementary Linear Algebra (Indonesian translation version) that was written by Howard Anton. In the process of constructing the concept maps, most of the students only used this textbook. They revealed that to be able to understand the materials on the book they read it several times as it was difficult for them to understand the new terms in the book. However, there were some students who tried to find other books as additional reference. They revealed that with using other sources they were helped to understand the material better. Sometimes, there were some parts that were difficult to understand in the main textbook but there was no simpler explanation in any other books. In this course, I didn’t give them the information about the additional books that they could use to support their learning. For my future teaching practice, I will inform them about other sources that they could use to support their learning.

Concept maps presentation was the opening session of the learning activities in the classroom. Every week, a group was given the opportunity to present the concept maps, after which there was a discussion. The concept maps presentations had triggered constructive discussions between students in the class. Through these discussions, the presenting group received a lot of inputs for improvement their concept maps. The inputs that the presents usually received were about the correction of misconceptions and misplaced concepts on the map, and additional materials that should be on the concept map. Actually, the benefits of all the inputs were not only for the presenters but also for all students in the class.

All the students in the class were prospective teachers. The opportunity to stand in front of the class and to explain the materials was a valuable experience for them. Through this presentation they have practiced to deliver the materials systematically using concept maps. All the experiences and knowledge that they
acquired through this process was valuable for them in preparation to become good teachers in the future.

During the early weeks of course (Weeks 2, 3, and 4), the concept maps presentation and discussion took longer (about 20 minutes) than expected. This was because the presenters were not sufficiently prepared. They lost much time to write or to stick the maps on the board. From Week 5 onwards, they were better preparing. They prepared their concept maps to be presented using a LCD projector, and they constructed the concept maps using Microsoft Power-point. By preparing well, they did presentation efficiently so that the time that they needed for the concept maps presentation and discussion was about 12 minutes. I think that teaching and learning process encouraged students to prepare the concept maps, with the lecturer giving them the opportunity to present their concept maps in front of the class.

*Presenting Materials by the Lecturer*

Before I used the ACE teaching cycle as an approach for my teaching practice I was involved in the traditional way of teaching where the instruction was teacher-centred. Using these two approaches, I acquired different experiences related to students’ responses to my presentation. In the traditional class, students’ responses were very minimal and they were reluctant to speak in the class. They would usually speak if the lecturer asked them questions or requested them to give their opinion. The frequently found that students asked to me to repeat my explanations. In the class using the ACE teaching cycle approach, I found the students displayed increasing initiative to speak in the class. They spoke more critically about the proving of theorems and the difficulties they experienced when solving mathematical problems. This was possible because they had learnt before coming to class.

At the beginning of the use of the ACE teaching cycle, I tried to present all the materials. Evidently, that way was not effective because students had to learn the materials first when they completed the concept maps task. Students acquired a
series of learning experiences through the concept maps tasks. First, when preparing to construct the concept maps they individually had to learn the topic using the textbook and other sources. Then, in constructing the concept maps they had to discuss the topic in their groups. Next, they had the opportunity to learn the topics through the presentation of concept maps at the beginning of the class. So, through this series of learning on the topics they acquired information and experience about the topics. For the next teaching practice using the ACE teaching cycle, I will not need to present all the topics. I will select the topics that will enable students to deepen their understanding like presenting an alternative method to prove the theorems and give examples that involve the use of complex concepts and procedures. Besides that, I could also save time to be used for other activities in the class.

Classroom Discussions Activity

Related to the use of the time for the discussion activity for both group discussions and classroom discussions, as a lecturer-researcher I saw that the time that I allocated was not enough for them to solve the problems that they faced. Next time that I use the ACE teaching cycle approach, I will allocate more time for these discussion activities. To increase the allocation time, one possible way is by reducing the time allocation for topics explanations by the lecturer. I think, that the time for explaining the topics by the lecturer could be reduced from 50 minutes to 30 minutes.

In group discussions, each group consisted four, five, or six students. Their membership did not change during the semester; all of them worked with same friends throughout the semester. Learning together with the same friends throughout the semester in a group has advantages and disadvantages. One of the advantages was that all members in a group came to know each other well so that this gave them the opportunity to be more organized and productive in their work. One of the disadvantages of having the same members in a group throughout the semester was that they did not have enough opportunity to be close with other
friends in the class. For the next practice using the ACE teaching cycle approach I intend not to set the same membership of the groups throughout the semester.

From my observations of the group discussions for one semester, I can say that the discussion groups had encouraged students to actively communicate their mathematics ideas with each other. From week to week, I saw them become more courageous to ask questions or to put forward ideas. In the early weeks of group discussion activities, they looked rather reserved and not all members of the group were actively involved in the discussions. Perhaps the reason for this was that they still required adapting to the new learning environment. Gradually, I saw them become more forthcoming and almost all members of the group were actively involved in discussions.

Class discussions also encouraged them to share their knowledge with others in the class. Most of the groups could not solve all mathematics problems correctly. They had the opportunity to understand the problems that they faced through classroom discussions, with a group that was not able to solve certain problems getting help from other capable groups. To resolve a problem that was raised by a group, a representative of another group was asked to explain their ideas in front of the class. In this way all students in the class who had the same problem also received help.

The weakness encountered in these discussions was the condition of the classrooms that were cramped, so the distance between the groups was too close. The classroom became noisy when the group discussions began. Certainly, it had an impact on the level of students’ concentration in the discussions. To improve my next teaching practice using this approach, using a more spacious classroom will be considered so that the discussions can proceed smoothly.

*Reflective Journals and Exercises*

At the beginning students experienced difficulty in writing their reflective journals because they had never done such a task before. However, I saw their seriousness
in doing the task. All students submitted all their reflective journals throughout the semester, although there were some students who were late in submitting them. The quality of their reflective journal writing improved with time. At first they only contained the main parts of the materials like the definitions and theorems. As they progressed, they added the opening and closing sessions and provided more detailed explanations. The reflective journal writing has facilitated students to explore what they had learnt. Their reflections allowed them to know which parts they already understood and which parts were difficult for them to understand.

At the end of the lecture, a student showed a compilation of reflective journals which she produced during the semester. It was a complete record of the lectures that she had followed, although I did not request students to compile all the reflective journals those they made. What the student showed to me was a positive effort. For my future teaching practice, I would suggest to all students to compile their reflective journals so that they will have a complete record of the experiences in their learning process.

However, based on the reflective journals that were written by students, I had the impression that what they wrote was like a repetition of the presentation of topics that they had learnt. Their reflective journal did not involve a critical analysis of the topics or their learning experiences. Perhaps the cause of this was the lack of guidance that was given to them in writing a reflective journal. For my future teaching practice, I will equip students with the proper knowledge about writing reflective journal. Besides that, the instruction or guidance which is given to students must enable them to be able to do reflections critically.

Completing mathematics exercises for homework is familiar to students. Almost all lecturers at the Mathematics Department of Padang State University give homework to their students. It is intended to provide practice opportunities for students to apply the knowledge they have acquired. Through the homework exercises activity in this ACE teaching cycle approach, students had the opportunity to improve their understanding on the topics that they had learnt. In
this study, students did this homework in their groups. Doing these mathematics exercises in groups had advantages and disadvantages. The advantage was that the students could foster cooperation and exchange of knowledge when solving problems. The disadvantage was that they became bound to the group; a student with weak motivation will wait for her or his friends’ answer to complete the homework. Working in the group to complete homework also reduced the level of their freedom in learning and practicing as their work become dependent on group necessity. In fact, personally they may have different needs. For my future teaching practice, working individually on doing exercises (homework) could be an option.

5.4 Implications of the Study for the Practice of Teaching Mathematics at College

The findings of the study showed that the use of the ACE teaching cycle in the Elementary Linear Algebra course at Padang State University gave the change on students’ engagement and students’ learning as expected by the researcher. Based on this result, mathematics lecturers at college could adopt this approach as an alternative strategy to be used in the teaching and learning process. In using this approach, lecturers need to pay attention to the preparation and implementation of the approach so that it will produce the intended results.

Lecturers who are interested in adopting the ACE teaching cycle as an approach in the teaching and learning process must pay attention to the students’ preparation before the use of the approach. Students need to know how to construct concepts maps, how to be involved in discussions, and how to write reflective journals. These knowledge and skills are needed by students before the implementation of the approach so that they can follow the teaching and learning process confidently from the beginning of the course.

The ACE teaching cycle approach adopts constructivist theory in its implementation. Lecturers who will use this approach to support their teaching practices need to know about constructivist theory in learning. Lecturers need to
realize that the concept map activity enables students to construct their understanding individually and uniquely through exploring their prior knowledge. Through classroom discussions, students have the opportunity to interact with others so that they have multiple perspectives on learning. Through completing exercises they have the opportunity to reflect on what they have learnt. The teaching and learning process based on the constructivist approach requires lecturers to become facilitators of knowledge acquisition. The lecturer’s role is to create experiences for learners and then guide them through those experiences. This allows the learners to construct their own knowledge through exploration (Doolittle, 2001; Rice & Wilson, 1999).

The ACE teaching cycle approach can be used as an alternative strategy in teaching mathematics to replace the conventional approach that is used by a lecturer. In the conventional teaching approach, students’ dependence to get knowledge and skills from the lecturer is very high and students’ independence in learning through various sources is limited. Students at college must have the opportunity to develop their ability to become independent learners. This ability will help them to grow in their careers. In college, students must also have the opportunity to develop their ability in socializing, discussing, and sharing ideas between them because these activities are very important to support their careers in the future (Dikici, 2006; Pedro & Brunheira, 2001). The ACE teaching cycle is a teaching approach that has possibility to accommodate students’ learning to achieve these qualities. So, mathematics lecturers at college should consider adopting the approach in their teaching practice.

5.5 Limitation of the Study

This research investigated the effects of the use of ACE teaching cycle approach in an Elementary Linear Algebra course at Padang State University. Based on the results of this study, caution must be taken in generalising the findings due to the limitations of the research. The limitations include the time frame, instrument used, and course implementation.
5.5.1 **Limited Time-frame**

The limited time-frame was one of the limitations of this research. This study was conducted over 14 weeks in one semester. I feel that the period of fourteen weeks implementation time is not long enough to facilitate participants’ maturity, because the approach that was implemented was something new for them. I think, they need more time to adapt so that they can follow the teaching and learning process confidently from the early weeks of the course. The instruction needs to be long enough to satisfy the quality criteria of prolonged engagement and persistent observation mentioned by Guba and Lincoln (1989). In terms of prolonged engagement and persistent observation, this study took place for one semester (January-June 2011). Along the semester, I was directly involved in the research as a lecturer-cum-researcher. I am familiar with the environment in which data collection was done because I have been a lecturer there for more than 19 years. So, I had enough time to conduct the research and to be fully involved in the study.

5.5.2 **Instrument Used**

The questionnaire instrument that was used in this study consisted of 55 statements that required responses on a five-point Likert-type scale. There was a possibility of students choosing a wrong option as a result of fatigue in completing the questionnaire, leading to non-response bias (Anderson, 2002). To overcome this problem, the researcher used other sources of data like focus group interviews and classroom observations. The data that were collected from various sources were used to verify each other. The use of triangulation of data from these sources within the research decreased the level of subjective bias.

5.5.3 **Course Implementation**

In this study, the researcher was also a lecturer and an observer who was involved in the data collection process. Being a lecturer-observer allowed the researcher and students to communicate with each other and share knowledge. This status of
the researcher could involve bias in the data collection and analysis. To counter the possibility of bias, the researcher used different sources of data like focus group interviews, a questionnaire, concept maps, students’ reflective journals, and lecturer’s research journal. The data that were collected from these different approaches is complementary to present a coherent picture to answer the research questions.

5.6 Recommendation for Further Research

This study used the ACE (Activity, Classroom discussion, and Exercise) teaching cycle as a strategy in teaching and learning of the Elementary Linear Algebra course. The Activity is an action before class that encourage students to learn so that they are equipped to discuss the materials in the class. For the Activity in this study, researcher used concept mapping. For Classroom discussion in this study, the researcher used the cooperative learning strategy where students discussed and worked together to solve mathematics problems. For Exercise in this study, the researcher used reflective journal writing and problem solving exercises that gave the opportunity to students to explore and improve their understanding.

For further research, the two areas those should be examined include, introduction/preparation time for the course and variation of activities in every stage of the ACE teaching cycle approach. The time for introducing a new approach is important. In this study, the time to introduce the new approach was very short (the researcher introduced it only in Week 1 of the course). For further study, students need more time for preparation so that they are able to better follow the teaching and learning process especially in developing the concept maps. This will give students the opportunity to be involved in meaningful learning activities by beginning earlier and continuing longer in the curriculum.

Further study can also be done through the replication of the three stages (Activity, Classroom discussion, and Exercise) of the ACE teaching cycle approach by changing the activities in each of them. This is intended to enable variation in the use of the approach. Having a variation in the approach will show that the
approach could not only be implemented using the activities that were used in this study but also by using other activities. The concept maps activity could be replaced with other activities encourage students to learn before class. As an example, lecturers could prepare worksheets that enable students to learn or facilitate them to learn through computer technology. The cooperative learning strategy that has been used in this study to facilitate discussion in the classroom could be changed to other ways of discussion. The reflective journal writing and problems solving exercises could also be changed to other students’ activities that enable them to improve their understanding.

Specifically, this study revealed the effects of the implementation of the ACE teaching cycle approach on students’ engagement and students’ learning. Further research could also be conducted to evaluate the effects of the approach to be more focused on aspects like students’ attitudes, motivation, and achievement. These dimensions are also related the students’ engagement and students’ learning but they were not evaluated in this study specifically.

In this research, the ACE teaching cycle strategy was implemented in the Elementary Linear Algebra course at Padang State University. For further research, it is possible to implement the strategy in other mathematics areas. The implementation is also possible in other levels of education, not only at university level. The use of the ACE teaching cycle approach is not limited to the Elementary Linear Algebra course or at university level.

5.7 Summary of the Chapter

This chapter has presented the conclusion and discussion of the major findings of the study that were obtained through data analysis. Besides that, this chapter also contained the background and aims of the study. This section informed about why this study was important and the benefits that would be achieved by this study. This chapter also included a summary of the methodology of the study related to action research, mixed methods research, instruments, participants, and teaching and learning procedures. These sections explained how the study was conducted.
This chapter also discussed the implications of the study for the practice of teaching mathematics at college, the limitations of the study, and suggestions for further study. As a lecturer and researcher in this study, I hope this research will contribute to the existing body of knowledge regarding the use of the ACE teaching cycle approach in the mathematics teaching and learning process.
References


Afamasaga-Fuata'i, K. (2009). Enhancing Undergraduate Mathematics Learning Using Concept Maps and Vee Diagrams

In K. Afamasaga-Fuata'i (Ed.), Concept Mapping in Mathematics (pp. 237-257): Springer US.

Alansari, W. M. (2010). Use of concept maps to improve Saudi pre-service teachers’ knowledge and perception of teaching social studies. (PhD), Curtin University, Perth.


D'mello, K. (2008). How can we maximise student engagement in the classroom? Retrieved from ree86.files.wordpress.com/.../maximising-engagement-presentation-3...


Lim, L., & Pugalee, D. K. (2004). Using journal writing to explore "they communicate to learn mathematics and they learn to communicate mathematically.". Ontario Action Research, 7(2).


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A. General Information

Study Program: Mathematics Education
Course Title: Elementary Linear Algebra
Course Code: MAT003
Credit Semester: 3
Lecturer: Drs. Hendra Syarifuddin, M.Si.

B. Course Description

1. The course is mandatory for every mathematics students and categorized as skill course.
2. Synopsis: system of linear equations, matrices, determinant, vector space, inner product space, linear transformation.
3. Standards of competency
   Students able to
   - Perform standard operations and elementary row operation (ERO) on matrices.
   - Determine the solution of any system of linear equations (SLE).
   - Find determinant and inverse of any quadratic matrix.
   - Use the properties of vector space to solve problems in vector space.
   - Use properties of inner product space and perform orthonormalization.
   - Use the properties of linear transformation.
4. Preceeding Course: Calculus 1, Calculus 2

C. References


D. Assessments

Midsemester test 30%
Final test 30%
Portfolio 40%
(concept map, group discussion, exercise, and reflective journal)
## E. Planned Schedule

<table>
<thead>
<tr>
<th>Week</th>
<th>Basic Competency (General aims)</th>
<th>Indicators (Specific aims)</th>
<th>Topics an Subtopics</th>
<th>Time Allocation (in classroom)</th>
<th>References</th>
</tr>
</thead>
</table>
| I    | Students understand the teaching and learning methods will be implemented | Students can understand:  
- The content and the aims of the subject.  
- The timeline for one semester.  
- The research that will be conducted.  
- How teaching and learning strategy will be implemented.  
- How the final mark will be determined.  
- Assessment  
- Portfolio  
- Concept Map  
- Group Work (Cooperative learning) | 1. SLE  
- Definition of SLE  
- Augmented matrix  
- ERO  
2. Gauss-Jordan Elimination  
- REM and RREM  
- Gauss-Jordan Elimination  
- Homogenous SLE | 3x50 minutes | Anton, p. 1-22 |
| II   | Students can determine solution of SLE | Students can  
1. Explain characteristics of row echelon matrix (REM) and row-reduced echelon matrix (RREM).  
2. Use ERO to determine the solution of SLE  
3. Analyze conditions of a SLE which has exactly one, infinite, or no solution. | 1. SLE  
- Definition of SLE  
- Augmented matrix  
- ERO  
2. Gauss-Jordan Elimination  
- REM and RREM  
- Gauss-Jordan Elimination  
- Homogenous SLE | 3x50 minutes | Anton, p. 1-22 |
### III
**Students can perform matrix operation and use properties of matrix to solve problems.**

- Students can explain definition of matrix and properties of special matrix.
- Check condition whether a matrix operation is defined or not.
- Perform matrix operations and their properties.
- Use the properties of transpose matrices.

<table>
<thead>
<tr>
<th>1. Matrices and Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Matrix definition</td>
</tr>
<tr>
<td>2. Equality of matrices</td>
</tr>
<tr>
<td>3. Matrix addition,</td>
</tr>
<tr>
<td>multiplication, and scalar</td>
</tr>
<tr>
<td>multiplication.</td>
</tr>
<tr>
<td>4. Properties of the</td>
</tr>
<tr>
<td>operation</td>
</tr>
<tr>
<td>5. Special forms of</td>
</tr>
<tr>
<td>matrices</td>
</tr>
<tr>
<td>6. Transpose matrices.</td>
</tr>
</tbody>
</table>

| 3x50 minutes | Anton, p. 23-49 |

### IV
**Students can find inverse of matrix and use properties of inverse**

- Students can recognize elementary matrix and write a matrix as product of elementary matrices.
- Find inverse of a matrix using simultan ERO.
- Check whether a matrix invertible or not.
- Use properties of inverse and invertible matrices.

<table>
<thead>
<tr>
<th>1. Elementary matrices</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Row equivalent</td>
</tr>
<tr>
<td>3. Inverse of matrix</td>
</tr>
<tr>
<td>4. Invertibility and SLE</td>
</tr>
</tbody>
</table>

| 3x50 minutes | Anton, p. 51-66 |

### V-VI
**Students can use the properties of determinant to solve problems**

- Students can find determinant using ERO.
- Find determinant using cofactor expansion.
- Use properties of determinant to solve problems especially to find inverse and to solve SLE which has exactly one solution.

<table>
<thead>
<tr>
<th>1. Determinant.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Determinant and ERO</td>
</tr>
<tr>
<td>3. Cofactor Expansion</td>
</tr>
<tr>
<td>4. Properties of determinant</td>
</tr>
<tr>
<td>5. Application of determinant</td>
</tr>
</tbody>
</table>

| 6x50 minutes | Anton, p. 81-118 |
| VII   | Students can determine whether a set is a vector space or not | Students can | 1. Real vector space  
2. General vector space  
3. Properties of vector space | 3x50 minutes | Anton, p. 204-210  
Perry, p. 166-175 |
|------|--------------------------------------------------|--------------|----------------------------------|--------------|----------------|

| VIII  | Students can determine whether a subset is a subspace or not and find relation between vectors in subspace. | Students can | 1. Subspace  
2. Linear combination  
3. Spanning set | 6x50 minutes | Anton, p. 211-230 |
|------|--------------------------------------------------|--------------|----------------------------------|--------------|----------------|

| IX    | MID SEMESTER EXAMINATION                             | Students can | 1. Linearly independent  
2. Basis and dimension  
3. Coordinate | 3x50 minutes | Anton, p. 231-245 |
|------|--------------------------------------------------|--------------|----------------------------------|--------------|----------------|

| X     | Students can find a basis and determine the dimension of a vector space. | Students can | 1. Determine a set whether linearly independent or dependent  
2. Check whether a set is a basis of subspace or not.  
3. Determine the dimension of a vector space  
4. Explain the relation between spanning set, linearly independent set, and dimension of a vector space. | 3x50 minutes | Anton, p. 231-245 |
<table>
<thead>
<tr>
<th>XI</th>
<th>Students can use rank and nullity of matrix to solve problems</th>
<th>Students can 1. Find a basis for row space and column space of a matrix. 2. Determine rank and nullity of a matrix. 3. Use the properties of rank and nullity to solve problems especially to solve SLE.</th>
<th>1. Row space and column space of matrix 2. Rank and nullity</th>
<th>3x50 minutes</th>
<th>Anton, p. 246-258</th>
</tr>
</thead>
<tbody>
<tr>
<td>XII</td>
<td>Students can use properties of inner product.</td>
<td>Students can 1. Determine whether a function is an inner product or not. 2. Use properties if inner product to solve problems especially about vector's norm, distance and position (angle) between two vectors.</td>
<td>1. Inner product space 2. Norm, distance, and angle between two vectors 3. Orthogonality</td>
<td>3x50 minutes</td>
<td>Anton, p. 276-297</td>
</tr>
<tr>
<td>XIII</td>
<td>Students can make orthonormal basis.</td>
<td>Students can 1. Determine orthogonal projection of a vector to another vector or set of vectors. 2. Make an orthonormal basis</td>
<td>1. Orthogonal projection 2. Orthonormal Basis 3. Gram-Schmidt Process.</td>
<td>3x50 minutes</td>
<td>Anton, p. 298-310</td>
</tr>
</tbody>
</table>
| XIV | Students can use properties of linear transformation (LT) to solve problems | Students can:
1. Check whether a mapping is a LT or not
2. Use properties of LT to solve problems
3. Determine a basis for kernel and range of a LT
4. Determine rank and nullity of a LT | 1. Linear Transformation (LT)
2. Properties of LT
3. Matrix of LT
4. Kernel and range of LT
5. Rank and nullity of LT | 3x50 minutes | Anton, p. 366-381 |
APPENDIX B

Student Engagement in the Mathematics Classroom Questionnaire
(English Version)

Directions for Students

These questionnaires contain statements about your engagement in studying mathematics. You will be asked how often each statement takes place.

There are no 'right' or 'wrong' answers. Your opinion is what is wanted. Think about how well each statement describes your engagement in studying mathematics.

Draw a circle around

1. If the practice takes place Almost Never
2. If the practice takes place Seldom
3. If the practice takes place Sometimes
4. If the practice takes place Often
5. If the practice takes place Almost Always

Be sure to give an answer for all questions. If you change your mind about an answer, just cross it out and circle another.

Some statements in this questionnaire are fairly similar to other statements. Don't worry about this. Simply give your opinion about all statements.

Practice Example

Suppose you were given the statement "I choose my partners for group discussion." You would need to decide whether you choose your partners 'Almost always', 'Often', 'Sometimes', 'Seldom' or 'Almost never'. If you selected 'Often' then you would circle the number 2 on your questionnaire.

<table>
<thead>
<tr>
<th>Cognitive Engagement</th>
<th>Almost never</th>
<th>Seldom</th>
<th>Sometimes</th>
<th>Often</th>
<th>Almost Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 I find memorising formula is the best way to learn mathematics.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2 In learning mathematics, I prefer memorising all the necessary formulas rather than</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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</tbody>
</table>

200
<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>3</td>
<td>I think memorising the fact and detail of a topic is better than understanding it holistically.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>In mathematics learning, it is very useful to memorise the methods for solving word problem.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>In mathematics learning, I prefer memorising different methods of solution; this is very effective way of learning.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>I think the best way of learning mathematics is to memorise facts by repeatedly working on mathematics problems.</td>
<td>1</td>
<td>2</td>
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<td>4</td>
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<tr>
<td>7</td>
<td>I think memorising mathematics is more effective than understanding it.</td>
<td>1</td>
<td>2</td>
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</tbody>
</table>

**Deep Strategy**

<p>| | | | | | |</p>
<table>
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</thead>
<tbody>
<tr>
<td>8</td>
<td>When I learn mathematics, I would wonder how much the things I have learnt can be applied to real life.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>When I learn new things, I would think about what I have already learnt and try to get a new understanding of what I know.</td>
<td>1</td>
<td>2</td>
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<td>4</td>
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<tr>
<td>10</td>
<td>When I read mathematics textbook, I would try to pick out those things which should be thoroughly understood rather than just reading next through.</td>
<td>1</td>
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<tr>
<td></td>
<td>Statement</td>
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<tr>
<td>11</td>
<td>I would try to connect what I learned in mathematics with what I encounter in real life or in other subjects.</td>
<td></td>
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<tr>
<td>12</td>
<td>I would spend out of class time to deepen my understanding of the interesting aspects of mathematics.</td>
<td></td>
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</tr>
<tr>
<td>13</td>
<td>In learning mathematics, I always try to pose questions to myself and these questions would help me understand the core of mathematics.</td>
<td></td>
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<tr>
<td>14</td>
<td>I would use my spare time to study the topics we have discussed in the class.</td>
<td></td>
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</tr>
</tbody>
</table>

**Reliance**

<table>
<thead>
<tr>
<th></th>
<th>Statement</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>The best way to learn mathematics is to follow the lecturer’s instructions.</td>
<td></td>
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<tr>
<td>16</td>
<td>The most effective way to learn mathematics is to follow the lecturer’s instruction.</td>
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<tr>
<td>17</td>
<td>I would learn what the lecturer teaches.</td>
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<tr>
<td>18</td>
<td>I would learn in the way the lecturer instruct me</td>
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<tr>
<td>19</td>
<td>I would solve problems in the same way as the lecturer does.</td>
<td></td>
<td></td>
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<tr>
<td>20</td>
<td>I solve problems according to what the lecturer teaches.</td>
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<tr>
<td></td>
<td>In the learning mathematics, no matter what the lecturer says, I will follow accordingly.</td>
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<tr>
<td>Affective Engagement</td>
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<tr>
<td>Interest</td>
<td></td>
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</tr>
<tr>
<td>22</td>
<td>In the mathematics class, I find the mathematics knowledge interesting and mathematics learning is enjoyable.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>23</td>
<td>I find mathematics learning pleasurable and I am interested in solving mathematics problems.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>24</td>
<td>I feel a sense of satisfaction when I do mathematics exercises in class.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>25</td>
<td>I am always curious to learn new things in mathematics and I find learning mathematics enjoyable.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>26</td>
<td>I feel excited when we start a new topic in mathematics.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>27</td>
<td>I am very interested to know how to solve new mathematics problems. Mathematics always gives me pleasure.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Achievement Orientation</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>28</td>
<td>Though mathematics learning is tough, I feel happy when I can finish the tasks.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>29</td>
<td>Though mathematics learning is boring, I am happy when I get good result.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Learning mathematics is tough, but to get good result, the effort is worthwhile.</td>
<td>1</td>
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</tr>
<tr>
<td>31</td>
<td>Learning mathematics is tough, but I am satisfied when I get good result after making an effort.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>32</td>
<td>Learning mathematics is tough, but I am happy as long as I can get good result.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>33</td>
<td>Though mathematics learning is tough, I get a sense of satisfaction when I get good result.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

*Anxiety*

<table>
<thead>
<tr>
<th></th>
<th>I find myself very nervous during mathematics test.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>I am worried in mathematics examinations.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>36</td>
<td>During mathematics examinations, when I come across problems that I cannot comprehend, I will feel very nervous.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>37</td>
<td>I am always afraid that I will get poor result in mathematics test.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>38</td>
<td>During mathematics test, when I come across problems that I cannot solve, I will feel very anxious.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

*Frustration*

<table>
<thead>
<tr>
<th></th>
<th>I feel uncomfortable when the teacher starts a new topic.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>39</td>
<td>I am tired of learning a new topic</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<td></td>
</tr>
<tr>
<td>41</td>
<td>I do not like attending mathematics classes.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>42</td>
<td>I dislike doing mathematics.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>43</td>
<td>I am tired of learning mathematics.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<td></td>
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<tr>
<td>Behavioural Engagement</td>
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<tr>
<td>Attentiveness</td>
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</tr>
<tr>
<td>44</td>
<td>I listen to the lecturer’s instruction attentively.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>45</td>
<td>In the discussion of new topics, I take an active part and raise my points.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>46</td>
<td>I really make an effort in the mathematics lesson.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>47</td>
<td>I concentrate very hard when the teacher introduces new mathematical concepts.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>48</td>
<td>I will use every means to understand what the lecturer teaches in mathematics.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>49</td>
<td>I always take part in the discussion in the mathematics class.</td>
<td>1</td>
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<td>5</td>
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<tr>
<td>Diligence</td>
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<tr>
<td>50</td>
<td>For difficult problem, I would study hard until I understand them.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>51</td>
<td>If I cannot arrive at the right answer straight away. I will try</td>
<td>1</td>
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</tr>
<tr>
<td>52</td>
<td>If I cannot tackle a problem, I would try again later.</td>
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</tr>
<tr>
<td>53</td>
<td>If I make mistake in solving problems, I will work until I have corrected them.</td>
<td></td>
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</tr>
<tr>
<td>54</td>
<td>If I work on problems persistently, I am sure that I will get the right answer.</td>
<td></td>
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</tr>
<tr>
<td>55</td>
<td>If I cannot solve a problem right away, I will persist in trying different methods until I get the solution.</td>
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</tbody>
</table>
APPENDIX C

Student Engagement in the Mathematics Classroom Questionnaire
(Indonesian Version)

Kuisiner Keterikatan Mahasiswa di Kelas matematika

Petunjuk untuk mahasiswa:
Kuisiner ini memuat pernyataan-pernyataan tentang keterikatan saudara dalam mempelajari matematika. Saudara diminta untuk memberikan jawaban seberapa sering setiap pernyataan Saudara alami.


Lingkarilah 1 jika kenyataannya Saudara Hampir Tidak Pernah mengalaminya.

Lingkarilah 2 jika kenyataannya Saudara Jarang mengalaminya.

Lingkarilah 3 jika kenyataannya Saudara Kadang-kadang mengalaminya.

Lingkarilah 4 jika kenyataannya Saudara Sering mengalaminya.

Lingkarilah 5 jika kenyataannya Saudara Hampir Selalu mengalaminya.

Yakinkanlah diri Saudara untuk menjawab semua pertanyaan. Jika Saudara berubah pikiran tentang suatu jawaban, silang jawaban tersebut dan lingkari jawaban Saudara yang baru.

Beberapa pernyataan dalam kuisiner ini mungkin ada kesamaannya, abaikan hal ini. Tetaplah fokus untuk memberikan pendapat saudara terhadap semua pernyataan.

Contoh:
<table>
<thead>
<tr>
<th>Keterikatan Kognitif</th>
<th>Strategi Permukaan</th>
<th>Hampir T. Pernah</th>
<th>Jarang</th>
<th>Kadang-kadang</th>
<th>Sering</th>
<th>Hampir Selalu</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Saya mendapati bahwa menghafal rumus adalah cara terbaik mempelajari matematika.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>Dalam mempelajari matematika, saya lebih suka menghafal semua rumus-rumus yang diperlukan daripada memahami prinsip-prinsip dibaliknya.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>Saya pikir menghafal fakta dan detail dari suatu topik lebih baik daripada memahaminya secara menyeluruh.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>Dalam mempelajari matematika, menghafal metode untuk menyelesaikan soal sangat berguna.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>Dalam mempelajari matematika, saya lebih suka menghafal berbagai metode; ini cara yang sangat efektif.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>Menurut saya pikir cara yang paling baik mempelajari matematika adalah menghafal fakta-fakta dengan latihan menyelesaikan soal matematika berulang-ulang.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>Menurut saya menghafal matematika lebih efektif daripada memahaminya.</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<td>5</td>
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</tbody>
</table>

208
<table>
<thead>
<tr>
<th>Strategi yang mendalam</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 Ketika saya belajar matematika, saya ingin tahu berapa banyak materi yang telah saya pelajari yang bisa diterapkan dalam kehidupan nyata/sehari-hari.</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<td>5</td>
</tr>
<tr>
<td>9 Ketika saya mempelajari sesuatu yang baru, saya berpikir tentang apa yang telah saya pelajari dan mencoba untuk mendapatkan suatu pemahaman baru dari apa yang saya tahu.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>10 Ketika saya membaca buku teks matematika saya berusaha memahaminya ketimbang hanya membaca lalu saja.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>11 Saya berusaha menghubungkan apa yang telah dipelajari dalam matematika dengan apa yang ada dalam kehidupan nyata atau dalam bidang ilmu lainnya.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>12 Saya akan menghabiskan waktu di kelas untuk memperdalam pemahaman saya tentang aspek-aspek yang menarik dari matematika.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>13 Dalam mempelajari matematika, saya selalu mengemukakan pertanyaan pada diri saya dan pertanyaan ini membantu saya memahami intisari matematika.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>14 Saya akan memanfaatkan waktu</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<td>5</td>
</tr>
</tbody>
</table>
luang saya untuk mempelajari topik-topik yang telah kami diskusikan di kelas.

<table>
<thead>
<tr>
<th>Keterangan</th>
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</thead>
<tbody>
<tr>
<td>15</td>
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<td>16</td>
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<td>20</td>
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<td>21</td>
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<table>
<thead>
<tr>
<th>Keterikatan Sikap</th>
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<tbody>
<tr>
<td>Ketertarikan</td>
</tr>
<tr>
<td>22</td>
</tr>
<tr>
<td>23</td>
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<td>26</td>
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<td>27</td>
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Orientasi Pencapaian

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<tr>
<th></th>
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<tbody>
<tr>
<td>28</td>
<td>Meskipun belajar matematika sulit, Saya merasa senang bila saya bisa menyelesaikan tugas-tugas.</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
<td>29</td>
<td>Walaupun belajar matematika membosankan, saya senang bila saya mendapat hasil yang baik.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
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<tr>
<td>30</td>
<td>Belajar matematika itu sulit, tetapi untuk mendapatkan hasil yang baik, usaha adalah sesuatu yang berharga.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>31</td>
<td>Belajar matematika itu sulit, tetapi saya puas bila saya mendapat nilai yang baik</td>
<td>1</td>
<td>2</td>
<td>3</td>
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</table>
setelah melalui suatu usaha.

<table>
<thead>
<tr>
<th>No</th>
<th>Masalah</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>Belajar matematika itu sulit, tetapi saya senang sepanjang saya bisa mendapatkan hasil yang baik.</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<td>5</td>
</tr>
<tr>
<td>33</td>
<td>Walaupun belajar matematika sulit, saya merasa puas bila saya mendapatkan hasil yang baik.</td>
<td>1</td>
<td>2</td>
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<td>5</td>
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Kecemasan

<table>
<thead>
<tr>
<th>No</th>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>34</td>
<td>Saya sangat gugup selama tes matematika.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>35</td>
<td>Saya merasa kuatir saat ujian matematika.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>36</td>
<td>Selama ujian matematika, bila saya menemui soal yang tidak mampu saya selesaikan, saya akan merasa sangat gugup.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>37</td>
<td>Saya selalu takut bahwa saya akan mendapat nilai jelek dalam tes matematika.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>38</td>
<td>Selama tes matematika, bila saya menemui soal yang tidak bisa saya selesaikan, saya akan merasa sangat cemas.</td>
<td>1</td>
<td>2</td>
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Frustasi

<table>
<thead>
<tr>
<th>No</th>
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<th>2</th>
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</thead>
<tbody>
<tr>
<td>39</td>
<td>Saya merasa tidak nyaman bila dosen memulai topik yang baru.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>40</td>
<td>Saya lelah mempelajari topik yang baru di kelas.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<tr>
<td>41</td>
<td>Saya tidak suka mengikuti pembelajaran matematika.</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
<td>No</td>
<td>Statement</td>
<td>1</td>
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</tr>
<tr>
<td>42</td>
<td>Saya tidak menyukai matematika.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>43</td>
<td>Saya lelah belajar matematika.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>44</td>
<td>Saya mendengarkan penjelasan dosen dengan penuh perhatian.</td>
<td></td>
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<tr>
<td>45</td>
<td>Dalam mendiskusikan topik yang baru, saya berperan aktif dalam mengemukakan pendapat.</td>
<td></td>
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<tr>
<td>46</td>
<td>Saya sungguh berusaha dalam pelajaran matematika.</td>
<td></td>
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</tr>
<tr>
<td>47</td>
<td>Saya berkonsentrasi sangat keras bila dosen memperkenalkan konsep matematika baru.</td>
<td></td>
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<tr>
<td>48</td>
<td>Saya akan menggunakan setiap pengertian untuk memahami apa yang diajarkan dosen.</td>
<td></td>
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<td></td>
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<tr>
<td>49</td>
<td>Saya akan selalu mengambil bagian dalam diskusi di kelas matematika.</td>
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<tr>
<td>50</td>
<td>Untuk masalah (soal) yang sulit, saya akan belajar keras sampai saya dapat memahaminya.</td>
<td></td>
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<td></td>
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<tr>
<td>51</td>
<td>Jika saya tidak dapat langsung menemukan jawaban yang benar, saya akan coba lagi</td>
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kemudian.

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<tbody>
<tr>
<td>52</td>
<td>Jika saya tidak dapat mengatasi suatu persoalan, saya akan mencoba lagi nanti.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>53</td>
<td>Jika saya membuat kesalahan dalam menyelesaikan masalah, saya akan bekerja sampai saya dapat memperbaikinya.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>54</td>
<td>Jika saya menyelesaikan soal secara terus menerus, saya yakin bahwa saya akan mendapatkan jawaban yang benar.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>55</td>
<td>Jika saya tidak dapat menyelesaikan soal dengan segera, saya akan berusaha sekuat tenaga mencoba metode lain sampai saya mendapatkan solusi.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
APPENDIX D

Focus Group Protocol

Main Questions:

1. Please tell me about your views about Mathematics! You may consider difficulties, uses, and enjoyment.

2. What can you tell me about learning/studying mathematics?

3. How is this approach for studying mathematics different from what you have previously experienced?

4. What some problems/difficulties have you faced in studying/learning mathematics using this approach?

5. How has this method affected your engagement in studying/learning mathematics?
Dear Students,

My name is Hendra Syarifuddin. I am currently completing a piece of research at the Science and Mathematics Education Centre at Curtin University of Technology. I invite you to consider taking part in the research of the new way in teaching and learning process of Elementary Linear Algebra course.

**Purpose of Research**

The research aims in the proposed study are to develop, implement, and evaluate the use of Activity, Classroom discussion, and Exercise (ACE) teaching cycle in Elementary Linear Algebra (ELA) course.

**Your Role**

In this research you will involve in the teaching and learning activity and data collecting process. I will observe your learning, engagement, and learning environment through the classroom observation, interview, and questionnaires. Your involvement in this research is voluntary. You have the right to refuse to not involve in this study. Your refusal will not influence on your marks entirely.

**Consent to Participate**

Your involvement in the research is entirely voluntary. You have the right to withdraw at any stage of the research without it affecting your rights or my responsibilities. When you have signed the consent form, I will assume that you have agreed to participate and allow me to use your data in this research.
Confidentiality

The information you provide will be kept separate from your personal details, and only myself and my supervisor will have access to this. The interview transcript will not have your name or any other identifying information on it and in adherence to university policy, the interview tapes and transcribed information will be kept in a locked cabinet for at least five years, before a decision is made as to whether it should be destroyed.

Further Information

This research has been reviewed and given approval by Curtin University of Technology Human Research Ethics Committee (Approval Number SMEC-49-10). If you would like further information about the study, please feel free to contact me on +61401065307 or by email hendrasy@yahoo.com. Alternatively, you can contact my supervisor: A/Prof. Bill Atweh on +61892667073 or B.Atweh@curtin.edu.au.

Thank you very much for your considerations on taking parts this research. Your participation is greatly appreciated.

Yours sincerely,

Hendra Syarifuddin
APPENDIX F

STUDENT’S CONSENT FORM

• I understand the purpose and procedures of the study.

• I have been provided with the participation information sheet.

• I understand that the procedure itself may not benefit me.

• I understand that my involvement is voluntary and I can withdraw at any time without problem.

• I understand that no personal identifying information like my name, address or school will be used in any published materials.

• I understand that all information will be securely stored for at least 5 years before a decision is made as to whether it should be destroyed.

• I understand that updates of the progress of the research will be provided to me.

• I have been given the opportunity to ask questions about this research.

• I agree to participate in the study outlined to me.

__________________________________________________________________

Name: _______________________________________________________

Signature: ___________________________________________________

Date: ____________________