UNIVERSITI PUTRA MALAYSIA

EFFECTS OF PROBLEM-BASED LEARNING ON COGNITIVE AND AFFECTIVE VARIABLES IN LEARNING STATISTICS AMONG UNIVERSITY STUDENTS

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By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Doctor of Philosophy

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Chairman: Associate Professor Rohani Ahmad Tarmizi, PhD

Faculty: Institute for Mathematical Research

Two phases of experimental study with randomized post-test only control group design were conducted to investigate the effects of problem-based learning on the cognitive and affect variables in learning statistics among university students. Experiments in Phase I and Phase II were conducted over a duration of 10 weeks lessons, each week consisted of three hours lesson. In the first phase of the study, two experimental groups, namely the Traditional Problem-based Learning (PBL-Tr) and the Web-basedProblem-based Learning (PBL-Web), and one control group were involved. The subjects of the study were graduate students who enrolled in an Educational Statistics course at a public university in Malaysia. The PBL-Tr group underwent learning using the traditional problem-based learning approach with guided questions and the PBL-

Web group underwent learning using problem-based learning approach with guided questions by using a website; and the control group underwent learning using conventional instruction. In Phase I, the three groups were compared on cognitive variables (overall statistical performance, statistical conceptual knowledge and statistical procedural knowledge) and affect variables (meta-cognitive awareness and motivation).

In Phase II another batch of graduate students who then enrolled in an Educational Statistics course at a public university in Malaysia participated in the study. In Phase II, three groups of students were administered the respective treatments and tested once again for the same attributes as that in Phase I and additional measures such as number of of errors made by the subjects during solving test problems, students' mental load assessment for all three groups and hence instructional efficiency index were obtained.

Four instruments were used in this study, namely Statistics Performance Tests, Paas Mental Load Rating Scale, Metacognitive Awareness Inventory and Motivation toward Learning Survey Questionnaire. The data for Phases I and II were analysed by using independent t-test and planned comparison test, ANOVA, ANCOVA and repeated measure ANOVA tests.

The study shows that the problem-based learning with guided questions approach enhanced students' overall performance and induced higher levels of metacognitive awareness and motivation toward learning with less mental load invested during the learning. These findings indicated that the PBL with guided questions with two different modes: traditional and by using a website instruction is superior in comparison to the conventional instruction, hence implying that integrating the use of this approach in teaching and learning of mathematics was more efficient than the conventional instruction strategy. Further, students in experimental groups showed an overall favourable view toward integrating the use of the PBL with guided questions in the teaching and learning of Statistics. Even though some students experienced difficulties during PBL with guided questions at the beginning, they confirmed that PBL improved their understanding of statistics. Hence, it may be concluded that both forms of PBL were effective for student learning.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

KESAN PEMBELAJARAN BERASASKAN MASALAH PADA PEMBOLEHUBAH KOGNITIF DAN AFEKTIF UNTUK PEMBELAJARAN STATISTIK DALAM KALANGAN PELAJAR UNIVERSITI

Oleh

SAHAR BAYAT

Januari 2012

Pengerusi: Profesor Madya Rohani Ahmad Tarmizi, PhD

Institut: Penyelidikan Matematik

Kajian eksperimen yang terdiri daripada dua fasa dengan reka bentuk *randomized post-test only control group* telah dijalankan untuk mengkaji kesan pembelajaran berasaskan masalah terhadap pembolehubah kognitif dan afektif dalam pembelajaran statistik dalam kalangan pelajar universiti. Kedua-dua eksperimen dalam Fasa I dan Fasa II telah dijalankan selama 10 minggu pengajaran. Dalam fasa pertama kajian, dua kumpulan eksperimen telah dilibatkan iaitu, kumpulan Pembelajaran Berasaskan Masalah Secara Tradisional dan Pembelajaran Berasaskan Masalah Melalui Laman-Web (PBL-Web) beserta satu kumpulan kawalan. Subjek kajian adalah pelajar siswazah

yang mengikuti kursus Statistik Pendidikan di sebuah universiti awam di Malaysia. Kumpulan PBL-Tr mengikuti pembelajaran menggunakan pendekatan pembelajaran berasaskan masalah secara tradisional dengan soalan-soalan berpandu dan kumpulan PBL-Web mengikuti pembelajaran menggunakan pendekatan pembelajaran berasaskan masalah dengan soalan berpandu secara atas talian atau menggunakan laman web; dan kumpulan kawalan menjalani pembelajaran menggunakan langkah secara konvensional. Ketiga-tiga kumpulan yang dikaji dibanding berdasarkan pembolehubah prestasi (prestasi statistik keseluruhan, pengetahuan konsep dalam statistik dan pengetahuan prosedur statistik), serta juga pembolehubah afektif seperti kesedaran meta-kognitif dan motivasi pelajar terhadap pembelajaran.

Bagi Fasa II, perbandingan yang sama juga dibuat bagi kumpulan *PBL-Tr, PBL-Web* dan pengajaran secara konvensional terhadap pembolehubah prestasi (prestasi statistik keseluruhan, pengetahuan konsep dalam statistik dan pengetahuan prosedur statistik), serta juga pembolehubah afektif seperti kesedaran meta-kognitif dan motivasi pelajar terhadap pembelajaran. Perbandingan juga dilalakukan ke atas indeks kecekapan pengajaran, beban mental dan jumlah bilangan kesalahan dalam kedua-dua ujian sebagai pembolehubah kognitif tambahan.

Empat instrumen telah digunakan dalam kajian ini iaitu, Ujian Prestasi Statistik, Skala Penilaian Beban Mental Paas, Kesedaran Metakognitif dan Motivasi terhadap Pembelajaran. Data untuk Fasa I dan II telah dianalisis dengan menggunakan ujian-t bebas dengan ujian *planned comparison*, ANOVA, ANCOVA dan ujian ANOVA, *repeated measures*.

Kajian menunjukkan bahawa pembelajaran berasaskan masalah dengan soalan-soalan berpandu meningkatkan prestasi keseluruhan pelajar dan juga tahap kesedaran metakognitif mereka serta motivasi yang lebih tinggi terhadap pembelajaran dengan makin berkurangnya beban mental yang digunakan semasa pembelajaran statistik. Dapatan ini menunjukkan bahawa PBL dengan soalan berpandu dalam dua mod pengajaran yang berbeza: PBL tradisional dan PBL dengan menggunakan pengajaran secara talian atau web adalah lebih baik berbanding dengan pengajaran secara konvensional, oleh itu memberi implikasi bahawa menyepadukan penggunaan PBL ini dalam pengajaran dan pembelajaran matematik adalah lebih cekap daripada pengajaran secara konvensional. Di samping itu, pelajar dalam kumpulan eksperimen telah memberi pandangan keseluruhan yang menggalakkan ke arah mengintegrasikan penggunaan PBL dengan soalan berpandu dalam pengajaran dan pembelajaran Statistik. Walaupun beberapa pelajar mengalami kesukaran semasa mengikuti pengajaran secara PBL dengan soalan berpandu pada peringkat awal, mereka mengesahkan bahawa PBL meningkatkan kefahaman statistik mereka. Oleh itu, boleh disimpulkan bahawa kedua-dua bentuk PBL adalah berkesan untuk pembelajaran dalam kalangan pelajar.

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dedicate this dissertation to them – to my beloved husband, Hamidreza Javanbakhti, my parents Zarir Bayat and Akram Bayat.

I certify that a thesis Examination Committee has met on -------------------------to conduct the final examination of Sahar Bayat on her thesis entitled "The Effect Of Problem-Based Learning On The Cognitive And Affect Variables In Learning Statistics Among University Students" in accordance with the Universities and College Act 1971 and the constitution of the University Putra Malaysia [P.U.(A) 106] !5 march 1998. The committee recommends that the student be awarded the doctor of philosophy.

Members of the Thesis examination Committee were as follows:

____

BUJANG KIM HUAT, PhD
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Date: __________________

This Thesis was submitted to the senate of the University of Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as followed:

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DECLARATIONS

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not currently, submitted for any other degree at Universiti Putra Malaysia or any other institution.

SAHAR BAYAT

Date:

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CHAPTER 1

INTRODUCTION

1.1 Background of the Study

The teaching and learning of mathematics is a complex and dynamic process involving interaction between previously acquired levels of understanding and conceptualization of mathematical knowledge. As such, many programs and policies in mathematics education have been implemented in order to improve the instructional approaches. Some of these program and policies have undergone tremendous changes over the years. For instance, the role of teachers and students in the process of learning has been changed and students are now not only passive observers, but are instead active learners, who develop new ideas to improve their learning. The teachers are now not only knowledge and information transmitters, but also function as leaders and facilitators guiding students in discovering knowledge (Idris, 2006).

Nowadays, Mathematics Curriculum is focused on students' needs to think mathematically rather than just doing mathematical computation. Students should be able to develop more complex, abstract, and powerful mathematical structures. This can dramatically enable them to solve a broad variety of meaningful problems. Furthermore, students ought to become autonomous and self-motivated in their mathematical activities such as learning and solving problems. In addition, the mathematics curriculum should emphasises on acquiring mathematical knowledge which consists of mathematical concepts and skills of problem solving.

The principles and standards for mathematics were published in 2001 by the National Council for Higher Education (NCHE). It recommended that all students need to learn mathematical concepts by understanding those concepts via building new knowledge from their prior experiences (NCHE, 2001). In addition, enhancing the level of affect variables such as meta-cognition, motivation and attitudes in mathematics learning, specifically during mathematics problem solving is also recommended in mathematics education. Lester (1994) states that, mathematics problem-solving ability has link to meta-cognition, attitude and mathematical ability. Middleton and Spanias (1999) assert that, the motivation to achieve is greatly influenced by success in mathematics. They also iterated that in learning mathematics, students at all levels must be engaged in solving more real-world problems which are complex or ill-structured.

However, research in problem solving in mathematics is not recent, with some past studies focusing on myriad aspects such as heuristics, instructional method, mental schemes and factors affecting word problem solving. Educational boards and councils has been advocating instruction where students are actively constructing their ideas and collaboratively engaging in tasks that emphasize the connection of mathematical knowledge to its application in mathematics education reforms (National Council of Teacher of

Mathematics (NCTM, 2000); National Research Council (NRC, 1996); American Association for the Advancement of Science (AAAS, 1993). They also emphasise the importance of understanding of not only the mathematical content but ways in which students engage in learning mathematics. Furthermore, the Conference Board of the Mathematics and Sciences (CBMS, 2001) advocates a reduction of content with deeper understanding in university mathematics learning.

In addition, in the last 20 years the importance and potential of statistics in many areas such as medicine, environment, economics, education, social studies, etc have been highlighted (Gattuso, 2006). He argued that in order to be critical in processing new information, understanding of how the information was generated and communicated, today's citizen need to have access to formal education in statistics. Thus, statistics is a part of the educational and political agenda of many countries. According to Gal (2000), statistics literacy is one of the goals of the syllabus when it comes to professional training in many diverse areas. Gal and Garfield (1997) reported that, the main goal of education in statistics is developing the ability to communicate statistically in order for pupils to understand and gain experience with statistical reasoning.

In relation to develop students' ability to communicate and reason statistically, Gattuso (2006) states that, traditional way in learning and teaching statistics need to be modified to the new approaches of instruction, because students need to have more opportunities to explain statistical processes, interpret statistical results or combine ideas about data. It also proposes that students need to learn mathematics with understanding and building the new knowledge from their prior experiences and knowledge. According to Gatusso (2006), one of the pedagogical approaches for an effective mathematics especially statistics teaching and learning is research-based teaching method which includes problem based learning and project based learning.

Problem based learning is a mode of learning which students engage in their learning by the given problem scenarios. In this approach, the learning process begins with a real-life problem which students need to solve by means of their prior knowledge and information and also using the collaborative strategy. In this learning mode the role of students as passive learner and teachers as knowledge transmitter have changed and sharing the findings and information by learners could lead to a solution to the problems (Burris, 2005). In addition, the NCHE (2001) also emphasizes on understanding the mathematical concept through active learning. It also proposes that students need to learn mathematics with understanding and building the new knowledge from their prior experiences and knowledge. To achieve this aim in mathematics teaching and learning, using a collaborative learning strategy seemed to be needed. In the collaborative learning environment, the construction of knowledge and understanding will be through articulation, negotiation and reflections on ideas. This collaborative learning environment is the ultimate goal of many implementation efforts in mathematics education (Hiebert & Carpenter, 1992). According to Hiebert and Carpenter (1992), students who had learned or had been taught collaboratively mathematics retained the acquisition of mathematical knowledge and transferred it to novel situations. This development on collaborative learning requires that effective teaching and learning be focused on conceptual understanding and mathematical problem solving rather than rote learning or memorizing mathematical procedures.

Besides collaborative learning, recent mathematics instruction, using technology has also consistently been one of the major emphases in the teaching and learning of mathematics. Use of technology by teachers assist students in increasing their understanding of the mathematics concepts and enables them to explore the ideas of mathematics. The integration of technology in mathematics instruction is essential in order for students to face challenges in everyday life with the advancement of science and technology (Curriculum Development Centre, Malaysia, 2005). In addition, the technology functions as an integral component or tool in the learning of contexts of mathematics (International Society for Technology in Education (ISTE), 2000). Earlier, Jonassen (1997) states that, integrating technology by instructors has opened a wide opportunity for instructors in the teaching and learning process for improving students' achievement.

Therefore, mathematics educators are encouraged to utilize new technology in their process of teaching. The increase use of technology in the classrooms has also changed the nature of mathematics instruction. Technology can be used at different levels for supporting and extending mathematical reasoning and sense making, gain access to mathematics content and problem solving context and for enhancing computational fluency. However, the use of technology in teaching cannot replace development of conceptual understanding, skills of problem solving and computational fluency. In a balanced mathematics program, using technology with the appropriate pedagogy does enhance mathematics teaching and learning (Patel, Gali, Patel & Parmar, 2010).

In countries where technology integration is made feasible in teaching both at schools and universities, researchers have been investigating effects of technology integration in teaching and learning. However, the important opportunity in mathematics learning is on how technology can be used in enabling the students to learn mathematics better (Baki, 2001; Güven & Karataş, 2003). In addition, it gives an opportunity to mathematicians to identify which technology could promote the development of students' thinking skills and students' higher-level cognitive skills (Baki, 2001). The contribution of technology in students' cognitive activities allows students to investigate, discover, hypothesize and think creatively in solving mathematics problems. The emergence of communication technology has increased interests to investigate the effects of technology in teaching as well as investigating the effects of integrating technology in instructional approach in order to increase learning. Researchers in various fields would investigate into specific subject matter such as science, history, language, mathematics, moral studies etc. for different types of ability (high versus low ability, at-risks versus non at -risks) or level (primary, secondary, undergraduate, postgraduate, aged, etc) of learners.

Many instructional approaches and integration of technology with instructional approach had been recently investigated. Some of these approaches were problem-based learning, project-based learning, actively learning, contextual learning, modular approach, etc with integration of web-based learning or collaborative web-based learning (Tarmizi & Bayat, 2010).

A collaborative web-based learning strategy which integrates computer technology and collaborative work and learning can be used as powerful tool of technology in mathematics learning. Tinio (2002) reports that this strategy enables learners from distributed places to work collaboratively and share information or their findings with other learners or instructor in order to enhance their knowledge and solve the problems they may face in the process of learning. Web-based collaboration introduces an exciting way of collaborating students in their learning and a powerful tool of communication between students and instructors. In this area, learners share information, solve problems and help each other to gain knowledge (Tinio, 2002).

According to Hart and Walker (1993), students' motivation towards learning is based on characteristics of classroom instruction which consists of understanding of subject matter, obtaining feedbacks to their questions, learning material, delivery tools and etc. Indeed, web-based collaboration can create different learning and communication environment, and produce flexible teaching and learning modes (Beevers, McGuire, Sterling & Wild, 1995; Middleton & Spanias, 1999). These flexible approaches allow learners to receive timely guidance from teachers and other learners regarding the problems that they faced during the learning.

Collaborative web-based learning (CWBL) and problem-based learning (PBL) at present are two powerful educational approaches in higher education (Carr, 2001). By combining a face to face instruction and CWBL approach in an educational environment the learning and teaching won't be limited to time and place. Each of the method mentioned above (PBL and CWBL) provide an opportunity for moving beyond the simple acquisition of contents to development of skills and needs for lifelong learning. The combination of these two approaches together could help students to achieve meaningful learning, resulting in a positive and cumulative impact on their progress. Combining PBL approach with CWBL may make an opportunity for instructors to create active and vibrant learning environments which enhance the learning process for the students. The communication among learners and instructor as a platform of collaborative discussions and accessibility to the online resources and information, knowledge and data with the PBL approach as an active learning mode may make great opportunity for mathematics instructors to enhance students' performance (Carr, 2001). The following sections discuss the concepts of problem-based learning and integration of web-based learning in PBL.

1.1.1 Problem-based Learning

Problem-based learning is described as a learning mode in which learning is driven through problem solving. This learning process begins with a real-life problem that is presented by a scenario. The students then need to solve the problem using their prior knowledge and given resources working in small groups collaboratively. The instructor provides guidance and monitoring during this process (Hmelo-Silver, Duncan & Chinn, 2007). Earlier, Nelson (1999) describes the problem scenario as being complex, hence students have difficulty in obtaining the correct solution to these problems. Students would normally possess insufficient information, and students need to identify what they need to acquire in order to solve the problems. Thus, for achieving the solution to the problem, students will need to interpret the problem, collect required information, devise possible solutions, assess options and offer conclusions.

Problem-based learning approach was applied in 1960s at the medical school of McMaster University in Canada. Shortly thereafter, other universities such as Limburg University at Maastricht in Netherlands, the Newcastle University in Australia and New Mexico University in United States employed the McMaster model of PBL. Problem-based learning approach was used for other fields such as business, health sciences, law, dentistry, engineering, education and so on. Figure 1.1 below indicates the PBL model proposed by Dean and Kuhn (2006).

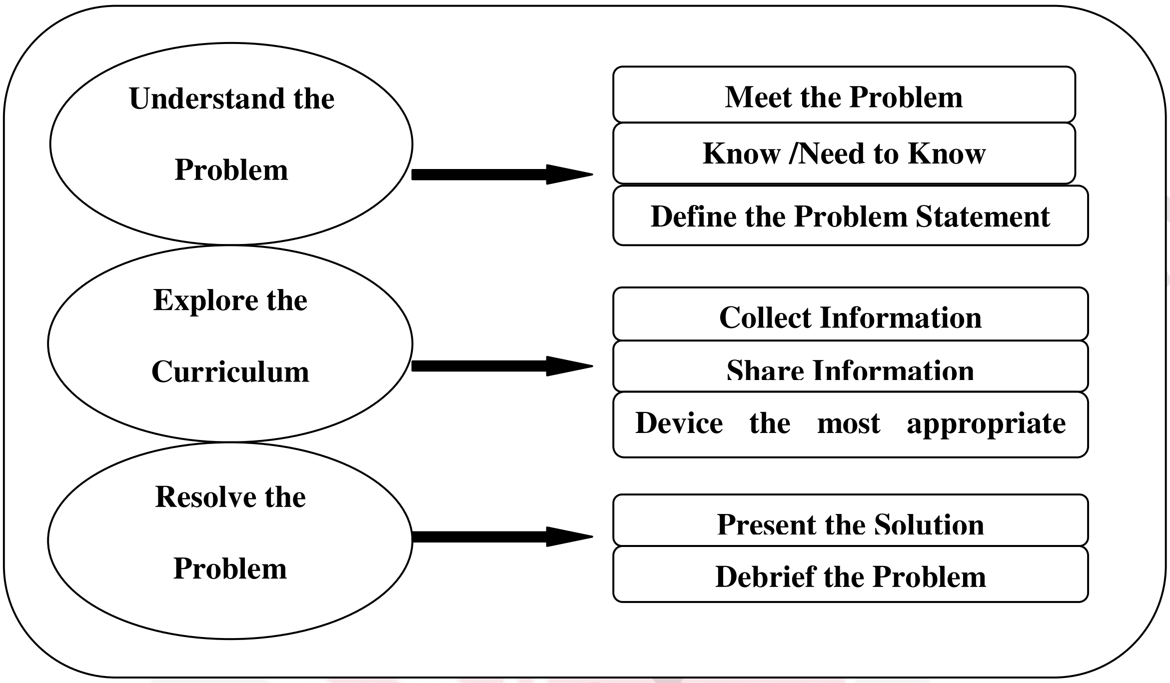

Figure 1.1. PBL approach

(http://pbln.imsa.edu/model/template/index.html)

Problem-based learning in mathematics is a strategy in integrating mathematics instruction with activities of problem solving and provides students with more opportunities for critical thinking, help students to present their own creative ideas and communicate mathematically with other students (Hiebert et al., 1996; Hiebert et al., 1997; Erickson, 1999; Krulik & Rudnick, 1999). Problem-based learning approach increases students' motivation toward learning because the scenarios present real life problems which students face in their lives or future careers (Cognition and Technology Group at Vanderbilt (CGTV), 1992). Problem-based learning is one possible method which enables learners to reflect and evaluate their experiences and learning activities (Dean & Kuhn, 2006).

In addition, in professional educational environments, PBL is an effective approach in collaborative learning (Derry & Hmelo-Silver, 2005; Hmelo-Silver, 2004). According to Hmelo-Silver (2004), cognitive apprenticeship is provided by the PBL approach in which students learn through real life problem solving and also by reflecting on their experience. In PBL mode of learning, students work in small collaborative groups, in which the instructor acts as a facilitator scaffolding the learning process. In PBL, students discuss concepts in depth and apply the concepts to practical problems, so they become highly trained to recognize how these ideas and reasoning are used in various problems. Problem-based learning has been increasingly popular in recent years due to several developments namely, (1) a growing call for bridging the gap between theory and practice (2) increasing information accessibility and knowledge feeding (3) the emergence of new possible ways of using multidisciplinary problems in learning (4) an educational emphasis on real-world competences (5) advance in learning areas of psychology, and pedagogy (Tan, 2004).

Many studies have revealed the positive effect of PBL on students' performance for both cognitive and affective domain (Cerezo, 2004; Elshafei, 1999). However, a few studies have suggested that PBL may not be effective if learning is not structured or given guidance (Colliver, 2000; Tarmizi, Ayub, Abu Bakar & Yunus, 2009). The guided questions are designed to facilitate and lead the following cognitive and meta-cognitive activities: deep conceptual knowledge about the materials, monitoring of understanding and comprehension and self checking their process of learning. Using collaborative strategy provides an opportunity for students to pose their questions, make explanation, receive elaboration, and construct argumentation. Elaboration, interpretation, explanation, and argumentation are central to the activity of the group, in which learning is supported by other individuals (Webb & Palincsar, 1996).

1.1.2 Web-based Learning

Web-based learning is a technologically-driven form of education which enables people to learn anytime and anywhere. It is a computer-assisted learning method, with additional support from teachers and other web-based learning resources. Ally (2004) defined web-based learning as use of internet to access the lesson materials or content, to interact with other learners or instructor and to gain support during the learning process and learning experience. The usage of web-based learning strategy has changed the form of delivering the course materials and ways the students' learn. By using a web-based learning environment, access to other resources such as papers, class notes, pictures, audio and video files will be feasible for students (Pascoe & Sallis, 1998). According to Gursul and Keser (2009) web-based learning may provide a dynamic presentation and multiple interactions with communication tools such as discussion boards, email, chat rooms and posting boards. The web-based PBL approach arouses motivation and engagement by connecting resources by using problems as triggers for learning and interactivity, hence increasing the potential of technology in education (Gürsul & Keser, 2009).

The importance of using PBL approach in teaching and learning has been recognized for many years (Fullen, 1992; Tobin & Dawson, 1992). However PBL as a student-centered approach is not easy to implement in the classroom as instructors do not have enough guidance or support in implementing the strategy (Blumenfeld, Soloway, Marx, Krajcik, Guzdial, & Palinscar, (1991); Kolodner, Camp, Crismond, Fasse, Holbrook, Puntambekar & Ryan, 2003). Later, several studies were conducted to investigate the use of guided questions as a scaffolding method which was used more broadly to describe additional forms of support during PBL mode of teaching and learning process (Tabak, 2004).

1.2 Related Learning Theories

The positive effects of the integration of PBL approach into the traditional or web-based learning in mathematics instruction can be understood by explaining the constructivist theory with three conditions (situated cognition, cognitive apprenticeship and multiple perspectives), social development theory, cognitive load theory, collaborative learning theory, computer-supported collaborative learning theory (CSCL). The following are discussions on the theories that support and provide framework for the use of PBL with guided questions in teaching and learning of mathematics.

1.2.1 Constructivism

Constructivism is one set of learning theories which is between cognitive and humanistic views. In constructivism, learning is active and constructive processes which theorize that learning will be facilitated since it provides learners with opportunities to construct knowledge in meaningful contexts of social environment; hence they have the chance to construct a comprehensive understanding. In constructivism the learner is an information constructor. Under constructivism theory, the focus is on making connection between facts and fostering new understanding in students. Instructors tailor their teaching strategies to students' responses and students are encouraged to analyze, interpret and predict information. They also rely heavily on open-ended questions and promote extensive dialogue among students (Duffy & Cunningham, 1996; Tobin & Tippins, 1993).

The PBL strategy with guided questions as an instructional approach can be supported based on constructivist views of learning in that knowledge is constructed by the students' previous knowledge. By negotiating the meaning with others, learners construct their own learning and make connections with prior notions and deal with content in a range of contexts. This approach gives a more active role to the students in their own learning in many classrooms in comparison with the traditional notions. In this approach, learning focuses on search for meaning (Moore & Kearsley, 2005).

As mentioned earlier, three different perspectives emerged under the constructivist theory. Firstly, the situated cognition is a theory of instruction that suggests learning is naturally tied to authentic activity, context, and culture (Brown, Collins, & Duguid, 1989). This theory refers to learning as an activity that occurs in a particular context and culture related to the learning tasks. This theory also relates that knowledge needs to be presented in an authentic context and students learn the lesson concepts in a social interaction and collaboration environment. In PBL with guided questions approach, students collaborate with each other and share their understandings. In this approach, concepts and information are processed more thoroughly while accounting for multiple opinions, perspective, or beliefs across the group. In addition, this approach gives an opportunity to students to work on a real-life problem which they must work out with diverse skills and information.

Secondly, cognitive apprenticeship which is situated within the social constructivist paradigm is a model of learning based on "learning-through-guided-experience", rather than based on physical skills and processes (Collins, Brown & Newman,1989). Cognitive apprenticeship suggests that students work on projects or problems in teams with close scaffolding of the instructor. Situated learning theory and the cognitive apprenticeship suggest that skills are acquired through authentic contexts by using collaborative strategy between peers and instructors about those contexts. In addition, according to Quintana and Soloway (2003) scaffolding is a key element of cognitive apprenticeship whereby students become good problem solvers with guidance of mentors, which scaffold students via their coaching, task structuring and hints without directly giving the final answers.

Hmelo-Silver and Barrows (2006) described scaffolding as supporters of students' learning on "how to do the task" and "why the task should be done in that way". Scaffolding not only guides learners through the complexities of the task, it may also highlight important aspects of students' work in order to force them to engage in their learning strategies (Reiser, 2004). This theory strongly support PBL approach with guided question, whereby the guided questions are scaffolds, which supports students learning while solving the problems without instructors directly giving the final answers.

Thirdly, based on the multiple perspectives of constructivist theory, students analyze facts and problems from multiple perspectives as most real life problems are complicated and hence the learners require skills in connecting the multiple ideas. In a constructivist classroom, instructional activities are students-centered and the instructor provides experiences, which allow students to hypothesize, manipulate objects, predict, pose questions, investigate, research, imagine and invent. This theory again, supports PBL approach in which the role of instructors as a facilitator allow students to be active learners for hypothesizing, predicting, researching, investigating in the process of learning.

1.2.2 Social Development Theory

Social development refers to qualitative changes in the structure and function of society that help society to better realize its aims and objectives. Social development consists of learning and application as two interrelated aspects.

Social interaction plays an important role in the process of cognitive development. One of the important elements in this theory is activity-based learning. Learners learn meaningfully by being actively engaged in their learning tasks. New ideas will be acquired and exchanged hence developing efficient communication skills. In the PBL approach students will share their experiences and information actively for meaningful learning (Coltman, Petyaeva & Anghileri, 2002).

1.2.3 Cognitive Load Theory

According to Sweller (2004), cognitive load theory (CLT) focuses on the role of working memory in researching on effective instructional methods. Cognitive load theory, which has a noteworthy role in learning, highlights connections between long-term memory (LTM) and short-term memory (STM). Sweller argues the importance of limitations of working memory which can be applied in designing instructional materials. Moreover, he argues that all conscious cognitive active learning takes place within a structure of learning that prevents all cognitive processes, other than the most basic ones. One of the main assumptions of the theory is that a learner's working memory is limited with regard to the amount of information. In the field of education, cognitive load is used to illustrate the amount of work imposed on working memory. According to this theory, if the overall cognitive load surpasses the total mental resources in the working memory, learning will fail. Hence, a well designed instruction minimizes extraneous cognitive load and optimizes germane cognitive load with a given essential cognitive load in order to enhance learning efficiency. Besides, if this type of instructional design is offered during the learning process, the total cognitive load does not go beyond the total mental resources.

In this theory, instruction should be designed in such a way that facilitates the acquisition of knowledge in long-term memory whereas unnecessary demands on the working memory are reduced. In addition, in this theory, if the information present in such a way that cognitive load falls within the working memory's limitations, speed and accuracy of understanding will be improved and deep understanding of contents will be facilitated (Kirschner, Sweller, & Clark, 2006). Using the appropriate ways for conducting PBL approach, implementing effective guidance by instructors, providing the sufficient resources and learning tasks can minimize extraneous cognitive load and optimize germane cognitive load.

1.2.4 Collaborative Learning Theory

Collaborative learning is an instructional approach for teaching and learning which involves groups of learners who work together for solving problems, completing tasks or creating products (Langer, Colton, & Goff, 2003). In the collaborative learning area, knowledge can be created when learners actively share their experiences and information. In the collaborative learning environment, students engage in a common task where, every individual is accountable for others and also students grouped together in search of understanding, meanings or solutions. Collaborative learning has been suggested as an excellent method of helping students to learn. The PBL approach with guided questions may be regarded as collaborative learning strategy as students work together to answer the guided questions and solve the problems, therefore the new concepts are obtained via group working in which each group member takes a leading role in his/her group (Nelson,1999; Schneider, 2007).

1.2.5 Computer-Supported Collaborative Learning Theory

Computer support collaborative learning is a pedagogical approach in which learning happens through social interaction using a computer or internet. This kind of learning takes place via constructing and sharing knowledge among participants by using technology for communication or as a common resource. Computer support collaborative learning is focused on how technology can enhance peer interaction and group working, and how learners' collaborate and facilitate sharing and distributing knowledge and expertise among community members using internet (Lipponen, 2002). Computer support collaborative learning is considered as one of the most promising innovations to improve teaching and learning with the help of modern information and communication technology (Lipponen, 2002; Lehtinen, Hakkarainen & Lipponen, 1999; Verschaffel, Lowyck, De Corte, Dhert & Vandeput, 1998). Problem-based learning using particular website is indeed a CSCL, whereby, in this approach communication, interaction and collaborative learning take place between instructors and learners on the web, anytime and anywhere.

1.3 Problem Statement

One paramount problem in mathematics education is the fact that many students are not able to grasp the concepts and understanding of mathematical learning and hence were not able to solve complicated mathematics problems. Thus, in order to improve mathematics learning and develop students' mathematical concepts, understanding and problem solving ability, attempts must be made to find instructional practices which promote conceptual development, problem solving, and higher level thinking in mathematics Mccormick (1997). Studies by Secada (1992), Strutchens and Zawojewski (1997) showed low mathematical performance, especially on tasks that assess conceptual understanding, mathematical reasoning, and problem solving among high school students.

Many researchers agree that traditional teaching of mathematics have limited effectiveness to fulfill learners' needs. For many students, learning mathematics, through listening to what their instructors say in the class, memorizing what their instructors do, and following the teachers' procedures without necessarily trying to understand the concepts have been a difficult task. Bransford, Brown, and Cocking (1999) point out that conceptual understanding is an important component of proficiency in mathematics. Those students who receive instruction limited to memorization of facts and procedures (lower level cognitive processes) have a more fragile understanding of mathematical concepts than do those who receive conceptually based instruction. In addition, many students have difficulty in applying the mathematics they learned in their daily lives or future careers (Ridlon, 1999). Recent research showed that students still do not perform well on mathematical tasks that require mathematical understanding and problem-solving skills even though they have significantly improved their mathematics computational skills (Reese, Miller, Mazzee, & Dossey, 1997). The authors suggested that, new and innovative methods in mathematics instruction are essential. Whilst numerous literature has shown positive evidence of problem-based learning for enhancement of learning in the field of medicine, engineering, biology, accounting, finance, etc it is thus aptly, to examine the use of problem-based learning as instructional innovations in mathematics instruction namely by incorporating PBL with guided questions approach in teaching and learning may improve the mathematics performance and understanding of students.

Moreover, in today's world of emerging classroom technology, there is crucial need of developing a deeper and more meaningful conceptual understanding, critical thinking and problem solving skills among learners. Although many studies have shown positive impacts use of technology, further studies have been suggested with regards to the utilization of technology (Engelbrecht, 2003; Tarmizi, et. al., 2009). In addition, utilizing technology, specifically, the web-based learning in teaching and learning mathematics may forecast some positive impacts (Alavi, 1994 ; Carr , 2001; Ally, 2004).

Based on current literature, few studies examined new and innovative approaches in teaching and learning of university mathematics. In addition, there are few empirical studies about implementing PBL approach in mathematics courses at the university level, which is unlike in the fields of medicine, architecture, business studies, engineering, etc. (Zamri & Lee, 2005). According to Zamri and Lee (2005), with recent development in university learning, the pedagogical approaches in university instructions have gained focus on student-centered learning, thus, teaching and learning for university students have shown some positive changes in recent years. However, these changes were not pertinent for the teaching of mathematics subjects in university, which are usually taught based on the lecture-centered approach.

On the higher education perspective, there is a general agreement that we have entered an era whereby higher education is a critical element in this knowledge society. Hence, this has placed a new demand on its teaching functions, with growing emphasis on real-life learning, lifelong learning and more flexible forms of higher education delivery. In that respect many higher educational institutions are turning to e-learning technologies for improving the quality of learning by means of access to resources, services, long distance collaborations and exchanges. However these changes raise mixed sense of optimism and scepticism hence requires further investigations (Britain & Liber, 2000; Stockley, 2004; Laurillard, 2005). Hence this study seeks to examine these optimisms and scepticisms in light of cognitive and affect domains.

While technology alone might not be the answer to all of higher education's problems, the benefits of utilizing technology, particularly for developing online collaborative activities are well documented (O'neill, Singh, & O'Donoghue, 2004). According to the authors, technology can serve as a powerful medium particularly for part time and working students who find class attendance requirements and study difficult. Students will require support in adapting to a potentially unfamiliar learning context but which may provide several benefits.

Specifically, for the education and social science area, many higher learning institutions have made educational or social statistics course as a compulsory course which acts as a trigger for in depth research in this field. However, many education and social science students view statistics as dull and that they must memorize many mathematics formulas for solving statistics problems. Thus, they often postpone enrolling in educational statistics courses to the end of their degree program because of their fear of statistics or anxieties surrounding their lack of knowledge base in statistics, and their feelings of uncertainty regarding the use or applications of statistics (Onwuegbuzie, 2004). Specifically, new and innovative methods in teaching educational or social statistics at higher education institutions are essential. Student-centered learning such as PBL and technology assisted instructions such as web-based learning may provide positive impact to learners.

Both face-to-face PBL instruction and web-based PBL may provide educational innovations with the support of constructivist theory, social development theory, cognitive load theory, and computer-supported collaborative learning theory. Face-to-face PBL may provide an opportunity for moving beyond the simple acquisition of statistical contents to development of skills and needs for lifelong learning with the use of problem scenarios. Web-based PBL may provide continuous educational environment for the learning and teaching of educational or social statistics which won't be limited to time and place. Traditional (face-to-face) and web-based PBL approach may provide opportunities for instructors to create active and vibrant learning environments which enhance the learning process for the students. The communication among learners and instructor as a platform of collaborative discussions and accessibility to the online resources and information, knowledge and data with the PBL approach as an active learning mode may make great opportunites for mathematics instructors to enhance students' performance. Hence this study will examined specifically the utilization of PBL mode of learning, namely, the traditional PBL (PBL-Tr) and the web-based PBL (PBL-Web) in the learning of Educational or Social Statistics.

1.4 Purpose of the Study

The purpose of this study is to investigate the effects of problem based learning with guided questions approach on university students' cognitive and affect variables in learning statistics. Consequently, three types of instructional strategies: traditional PBL with guided questions, web-based PBL with guided questions and conventional instruction (Conv) which is a lecture-centered approach, were compared. The traditional PBL (PBL-Tr) and web-based PBL (PBL-Web) as two instructional strategies were different with respect to its delivery method in which the face-to-face method was used for the traditional PBL whilst the web-platform was used for the web-based PBL. Guided questions were designed as scaffolds providing guidance for students to connect their prior knowledge to new situation in solving statistics problems.

1.4.1 Objectives and Hypotheses – Phase I

This phase involves three approaches, namely, PBL-Tr, PBL-Web and Conv. In order to examine the effects of these approaches, several cognitive-related variables and affect variables are considered and measured. Specifically, the objectives of experiment in Phase I are:

1. To compare the effects of PBL-Tr, PBL-Web and Conv approaches on students' overall statistical performance.
2. To compare the effects of PBL-Tr, PBL-Web and Conv approaches on students' statistical performance in conceptual knowledge.
3. To compare the effects of PBL-Tr, PBL-Web and Conv approaches on students' statistical performance in procedural knowledge.
4. To compare the effects of PBL-Tr and PBL-Web and Conv approaches on students' overall statistical performance over repeated times (basically, performance on Statistics Test 1 and Statistics Test 2 or conduct of tests at Time 1[Statistics Test 1] followed by Time 2 [Statistics Test 2]).
5. To compare the effects of PBL-Tr and PBL-Web approaches on students' invested mental load during processing of statistics problems.
6. To compare the instructional efficiency index in learning statistics between the PBL-Tr and PBL-Web approaches.

7. To compare effects of PBL-Tr and PBL-Web approaches on students' overall meta-cognitive awareness when solving statistics problems.

8. To compare effects of PBL-Tr and PBL-Web on students' meta-cognitive awareness subscales (knowledge of cognition and regulation of cognition) during solving statistics problem.

9. To compare effects of PBL-Tr and PBL-Web on students' motivation toward statistics learning.

10. To compare effects of PBL-Tr and PBL-Web on students' motivation towards learning subscales (attention, relevance, confidence and satisfaction) in learning statistics.

The null hypotheses are as follows:

H_o1 There is no significant difference in the mean overall statistical performance between the PBL-Tr, PBL-Web and Conv groups.

H_o2 There is no significant difference in the mean statistical performance in conceptual knowledge between the PBL-Tr, PBL-Web and Conv groups.

H_o3 There is no significant difference in the mean statistical performance in procedural knowledge between the PBL-Tr, PBL-Web and Conv groups.

H_o4 There is no significant difference in the mean overall statistical performance between PBL-Tr, PBL-Web and Conv groups over repeated times (basically, performance on Statistics Test 1 and Statistics Test 2 or conduct of tests at Time 1[Statistics Test 1] followed by Time 2 [Statistics Test 2]).

H_o5 There is no significant difference in the mean mental load invested during processing of statistics problems between the PBL-Tr and PBL-Web groups.

H_o6 There is no significant difference between the PBL-Tr and PBL-Web groups in their instructional efficiency index.

H_o7 There is no significant difference between the PBL-Tr and PBL-Web groups in students' mean overall meta-cognitive awareness when solving statistic problems.

H_o8_A There is no significant difference between the PBL-Tr and PBL-Web groups in students' mean knowledge of cognition subscale when solving statistic problems.

H_o8_B There is no significant difference between the PBL-Tr and PBL-Web groups in students' regulation of cognition subscale when solving statistic problems.

H_o9 There is no significant difference between the PBL-Tr and PBL- Web groups in students' overall motivation toward statistics learning.

H_o10_A There is no significant difference between the PBL-Tr and PBL-Web groups in students' motivation for attention subscale in statistics learning.

H_o10_B There is no significant difference between the PBL-Tr and PBL-Web groups in students' motivation for relevance subscale in statistics learning.

H_o10_C There is no significant difference between the PBL-Tr and PBL-Web groups in students' motivation for confidence subscale in statistics learning.

H_o10_D There is no significant difference between the PBL-Tr and PBL-Web groups in students' motivation for satisfaction subscale in statistics learning.

1.4.2 Objectives and Hypotheses – Phase II

In this phase, effectiveness of PBL-Tr, PBL-Web and Conv approaches on cognitive-related variables and affect variables were also considered:

1. To compare the effects of PBL-Tr, PBL-Web and Conv approaches on students' overall statistical performance.
2. To compare the effects of PBL-Tr, PBL-Web and Conv approaches on students' statistical performance in conceptual knowledge.
3. To compare the effects of PBL-Tr, PBL-Web and Conv approaches on students' statistical performance in procedural knowledge.
4. To compare the effects of PBL-Tr and PBL-Web and Conv approaches on students' overall performance in learning statistics over repeated times (performance on Statistics Test 1 and Statistics Test 2 or conduct of tests at Time 1[Statistics Test 1] followed by Time 2 [Statistics Test 2]).
5. To compare the effects of PBL-Tr, PBL-Web and Conv approaches on students' invested mental load during processing of statistics problems.

6. To compare the instructional efficiency index in learning statistics between the PBL-Tr, PBL-Web and Conv approaches.
7. To compare effects of PBL-Tr, PBL-Web and Conv approaches on overall students' meta-cognitive awareness when solving statistics problems.
8. To compare effects of PBL-Tr, PBL-Web and Conv approaches on meta-cognitive awareness' subscales (knowledge of cognition and regulation of cognition) when solving statistics problem.
9. To compare effects of PBL-Tr, PBL-Web and Conv on students' motivation toward statistics learning.
10. To compare effects of PBL-Tr, PBL-Web and Conv on students' motivation towards learning subscales (attention, relevance, confidence and satisfaction) in learning statistics.
11. To describe opinions of the PBL-Tr and PBL-Web students on the teaching and learning approaches.

With regard to the above-mentioned objectives, the following hypotheses were tested.

H_o1 There is no significant difference in the mean overall statistical performance between the PBL-Tr, PBL-Web and Conv groups.

H_o2 There is no significant difference in the mean statistical performance in conceptual knowledge between the PBL-Tr, PBL-Web and Conv groups.

H_o3 There is no significant difference in the mean statistical performance in procedural knowledge between the PBL-Tr, PBL-Web and Conv groups.

H_o4 There is no significant difference in the mean overall statistical performance between PBL-Tr, PBL-Web and Conv groups over repeated times.

H_o5 There is no significant difference in the mean mental load invested during processing of statistics problems between the PBL-Tr, PBL-Web and Conv groups.

H_o6 There is no significant difference between the PBL-Tr, PBL-Web and Conv groups in their instructional efficiency index.

H_o7 There is no significant difference between the PBL-Tr, PBL-Web and Conv groups in students' mean overall meta-cognitive awareness when solving statistic problems.

H_o8_A There is no significant difference between the PBL-Tr, PBL-Web and Conv groups in students' mean knowledge of cognition subscale when solving statistic problems.

H_o8_B There is no significant difference between the PBL-Tr and PBL-Web groups in students' mean regulation of cognition subscale when solving statistic problems.

H_o9 There is no significant difference between the PBL-Tr, PBL-Web and Conv groups in students' overall motivation toward statistics learning.

H_o10_A There is no significant difference between the PBL-Tr, PBL-Web and Conv groups in students' motivation for attention subscale in statistics learning.

H_o10_B There is no significant difference between the PBL-Tr, PBL-Web and Conv groups in students' motivation for relevance subscale in statistics learning.

H_o10_C There is no significant difference between the PBL-Tr, PBL-Web and Conv groups in students' motivation for confidence subscale in statistics learning.

H_o10_D There is no significant difference between the PBL-Tr, PBL-Web and Conv groups in students' motivation for satisfaction subscale in statistics learning.

1.5 Significance of Study

One of the greatest challenges in education is to engage students in the learning process and to keep them interested in learning. Problem- based-learning as an educational innovation has promised to bring about greater engagement through self-directed and collaborative problem–solving processes. Current empirical research will provide evidence for the impact of PBL with guided questions on students' performance, meta-cognitive awareness and motivation towards statistics learning. In addition, the approaches implemented in this study may be adopted for more effective mathematics classroom practices. The PBL approach with guided questions may provide evidence that learning of statistics is an enjoyable experience when applied in real-life problems through problem scenarios. Therefore, this study provides an opportunity for both school teachers and university instructors to implement teaching of statistics using traditional PBL or as web-assisted learning through closely adapting the methodology employed in their teachings. Subsequently, these approaches may provide enhancement of students' performance, meta-cognitive awareness, and motivation toward learning.

This study will be of interest to educators, especially those who are interested in the use of new approaches in teaching statistics. PBL with guided questions as an instructional mode allows for flexible adaptation of guidance in teaching mathematics. More specifically, this study presents the multiple strategies such as presenting the sufficient resources, guided questions, assessment questions, providing collaborative learning environment, interacting between teacher and students in which intrinsic extraneous and germane cognitive load can be managed through PBL approach with guided questions.

Findings of this study provide guidelines in constructing PBL with guided questions as an instructional approach which allows for flexible adaptation of guidance. Researchers have reported that instructors experience frustration with the amount of time it takes to plan for and implement problem-based experiences (Simons, Klein & Brush 2004). Gallagher (1997) reports the difficulty faced by instructors in transforming learning experiences from passive students roles to more active roles (Gallagher, 1997). Brinkerhoff and

Glazewski (2004) reports that instructors struggle to construct effective assessment of students learning. Hence, without adequate support, the adoption of PBL methods is likely to be extremely limited. In this study, problem based learning (PBL) with guided questions as an instructional approach can support instructors as they adopt new roles, facilitate students inquiry, provide ongoing formative feedback, and implement new types of classroom management strategies.

PBL approach with guided questions in this study provides a model for mathematics instructors especially for statistics teachers to implement this approach in order to increase students' learning and understanding in mathematics. This study will be added value to the many researches and studies conducted on PBL, more specifically, for teaching of mathematics in the university. It provides new insights for researchers who are going to conduct PBL with guided questions in university mathematical courses. A key feature of this study is the integration of the guided questions and assessment problems as two scaffolding strategies which further support students learning.

On the higher education perspective, the use of traditional PBL allow the growing emphasis on real-life learning, lifelong learning and more flexible forms of higher education delivery. With respect to e-learning technologies for improving the quality of learning by means of access to resources, services, long distance collaborations and exchanges, the PBL-Web provide models of innovation in teaching in higher educational institutions. While technology alone might not be the answer to all of higher education's problems, the benefits of utilizing technology, particularly for developing online collaborative activities are well documented (O'neill, Singh, & O'Donoghue, 2004). In this study, this technology, the PBL-Web, can serve as a powerful medium particularly for part time and working students who find attendance requirements and study difficult.

1.6 Limitation of study

There are several limitations in the first and second phase of study:

- In both phases, the sample chosen was restricted to the graduate students of Faculty of Educational Studies. Thus, the findings of the study can only be generalized to similar sample of university students who were majoring in psychology, sociology, sports science, pedagogy, curriculum and instructions, guidance and counseling, language, etc.
- Majority of the graduate students were adult and working in private or government sectors. Thus, the PBL-Tr and PBL-Web mode of learning may have benefited fully these types of students whilst may not be beneficial to the fresh undergraduates or school learners.
- The course chosen was Educational Statistics and the intervention done was over 10 weeks of teaching sessions (three hours per week). Thus, whilst the mode of learning benefited the majority of the students, the results are suitably generalized to courses of similar contents and level. Therefore the findings are limited to Educational Statistics courses.

Further investigation is warranted for generalizing to overall mathematics learning.

- In both phases of study, mortality was a threat, because some students of PBL-Web group in Phase I and Phase II dropped out the Educational Statistics course, hence the number of students accounted for in the group is low. However, based on the results of pre-performance test and pre-test of meta-cognitive awareness indicated that the experimental (PBL-Web group) and Conv groups were homogenous in the both phases of the study.

1.7 Definition of Terms

The following are the definition of terms that were used in this study. The terms used are traditional problem based learning with guided questions approach (PBL-Tr), problem based learning with guided questions by using website (PBL-Web), conventional teaching approach (Conv), motivation towards learning, meta-cognitive awareness, overall performance, conceptual knowledge, procedural knowledge, mental load, instructional efficiency index and total number of errors obtained in statistics problem solving.

1.7.1 Traditional Problem-Based Learning with Guided Questions

Problem based learning (PBL) is utilized by posing contextualized problems (Rheem, 1998), real world and ill-structured problems (Fenwick, 2002; Jones, 1996) in a framework of support that provides resources, guidance, and instruction to learners as they acquire conceptual and procedural knowledge. In

PBL approach the learning process is cyclical with presentation of solution to the problems. Learners work collaboratively to solve the ill-structured and complex problem. Learners are required to analyze the problem, organize their ideas and prior knowledge, and identify relevant facts and issues of learning within their groups.

In this study, traditional PBL with guided questions is defined as an educational approach in which teaching and learning begins with a real-life ill-structured problem, which is embedded in the problem scenario. Each scenario is followed by guided questions related to the statistics topic which students were required to answer. In addition, students were also asked to solve the assessment problems which were presented to them as practice problems. The learning resources such as lecture notes and the relevant chapter are provided in order to guide the students in answering the guided questions and assessment problems. Students work in groups of three or four in answering the guided questions (Appendix A1) and solving the assessment problems (Appendix A2) in and out of class.

1.7.2 Web-based Problem-Base Learning with Guided Questions

The web problem-based learning combines the components of web-based learning strategy with the components of problem-based learning approach, including transmitting the lesson materials, synchronous and asynchronous communications and presenting the solution of the assessment problems by a representative of each group in the following class Lipponen (2002).

Synchronous communication refers to face to face arguments and discussions among teacher and learners, whereas in asynchronous communication, teacher and learners interact through Discussion Board or Chat Room to discuss problem faced by students everywhere and every time Jonassen (1995). In web-based learning, a variety of technologies are implemented to connect learners to each other and their instructors across a distance via website tools. Learners access course materials and interact with each other and the instructor as they work to achieve curricular goals of the course or the program (Palloff & Pratt, 1999).

In this study, the web-based PBL with guided questions was implemented via a website which was developed by the researcher. This website can be accessed at the following address www.pblelearning.com (Appendix B1). The website contains problem scenarios, question with guided-questions, learning resources, and assessment problems and were presented to students by simply accessing the tools or links on this website. Learners' communications in the process of solving the problems and answering the guided questions was recorded via Discussion Board (Appendix B2). The instructor provides assistance via the Discussion Board and Chat Room whenever possible. Students' answers to the guided questions and solutions to the assessment problems were submitted via email. The answers to the assessment problems are also presented by using Power-point by each group representatives in the following class.

1.7.3 Conventional Teaching and Learning

For the purpose of this study, the conventional instruction strategy was a whole-class instruction. The following are the activities, which were used by the teacher in the classroom:

i. Instructor explains the statistical concepts using the Power-point presentations and the whiteboard.
ii. Instructor explains on how to solve statistics problems related to the concepts explained.
iii. Instructor are given statistics problems to be solved individually.
iv. Instructor handles discussion of the problem solving.

1.7.4 Motivation toward Learning

Motivation is defined as an explanation of the direction and magnitude of behavior, or in other words, it explains what goals people choose to pursue and how actively or intensely they pursue them Keller (1987). Based on Keller (1987) model, motivation is subcategorize into four namely, Attention, Relevance, Confidence, Satisfaction, hence abbreviated as ARCS. These categories enable us to quickly gain an overview of the major dimensions of human motivation, especially in the context of learning motivation, and how to create strategies to stimulate and sustain motivation in each of the four areas.

In this study, motivation was considered as the type of motivation which students have toward the learning of statistics that is stimulated through the different teaching and learning approaches (PBL-Tr, PBL-Web, Conv). Motivation was measured based on the ARCS model created by Keller. The questionnaire consisting of 36 items measure learners' motivation based on the use of PBL-Tr, PBL-Web or Conv type of learning (Appendix C). In essence, this questionnaire measures students' reaction to the motivational features of instructional materials in terms of attention, relevance, confidence and satisfaction and overall motivation (Song & Keller, 2001). Attention refers to students' arousing and sustaining curiosity and interest, relevance refers to learners' needs, interests, and motives, confidence refers to students' positive expectation for successful achievement and satisfaction refers to students' extrinsic and intrinsic reinforcement for effort (Keller, 1999).

1.7.5 Meta-cognitive Awareness

According to Schraw and Dennison (1994), meta-cognitive awareness refers to one's ability of reflect, control and understand in one's own learning and cognitive activities. Another definition of meta-cognitive awareness refers to Flavell (1976), which states that meta-cognitive awareness refers to the awareness and monitoring of thoughts and task performance of one's, thinking about thinking. It refers to higher order mental processes involved in learning, such as making plans for learning or problem solving, using appropriate skills and strategies to solve a problem, making estimates of performances, and calibrating the extent of learning. Meta-cognitive knowledge and meta-cognitive regulation are two components of meta-cognitive awareness (Schraw & Moshman, 1995). Meta-cognitive knowledge is defined as knowledge of cognition which refers to knowledge of skills and strategies which work best for students, and how and when need to use these skills and strategies. Meta-cognitive regulation refers to activities which control one's thinking and learning such as planning, monitoring and evaluation.

Schraw and Dennison (1994) identify eight meta-cognitive strategies such as monitoring, procedural knowledge, declarative knowledge, and conditional knowledge, evaluation, debugging strategies, information management strategies and planning. These eight components were classified into two subscales, knowledge of cognition (procedural knowledge, declarative knowledge, and conditional knowledge) and regulation of cognition (monitoring, evaluation, debugging strategies, information management strategies and planning).

In this study, meta-cognitive awareness refers to students' perception and thinking of their ability related to knowledge of cognition (consisting of procedural knowledge, declarative knowledge, and conditional knowledge) and regulation of cognition (consisting of monitoring, evaluation, debugging strategies, information management strategies and planning) while solving the statistics problems. In this study, a 52-item bipolar-scale self-report Meta-cognitive Awareness Inventory (MAI) for adults was adapted from Schraw and Dennison (1994) to measure students' overall meta-cognitive awareness and its two subscales (knowledge of cognition and regulation of cognition) when students were learning statistics (Appendix D).

1.7.5.1 Knowledge of Cognition

Knowledge of cognition includes three sub processes that facilitate the reflective aspect of metacognition which includes declarative knowledge, procedural knowledge and conditional knowledge (Artzt & Armour-Thomas, 1992). In this study, knowledge of cognition refers to students' perception from their ability to organize the information related to the statistics problems, control over how to solve statistics problems and recognize the most important information in the problems when they solve statistics problems (Appendix D). Altogether 17 items with response of Yes or No were used to measure the level of meta-cognitive awareness for the knowledge of cognition subscale.

1.7.5.2 Regulation of Cognition

Regulation of cognition includes a number of sub processes that facilitate the control aspects of learning. Five component of regulation include planning, information management strategies, comprehension monitoring, debugging strategies and evaluation (Artzt & Armour-Thomas, 1992). In this study, regulation of cognition refers to students' perception from their ability to set and allocate resources prior to learning and organizing their time during statistics problems. It also include perception on checking several ways to solve statistics problems and choosing the best answer, focusing on the meaning and significance of new information of the statistics problem, drawing pictures or diagrams to help them understand while solving statistics problems, reviewing their problem solving process and etc. Altogether 35 items with response of Yes or No were used to measure the level of meta-cognitive awareness for the regulation of cognition subscale (Appendix D).

1.7.6 Overall Performance

According to Eggen and Kauchak (2004), performance is defined as a cognitive perspective in which learners learning and understanding were evaluated. In this study, overall performance refers to the total scores from Statistics Test I and Statistics Test II which were conducted during and at the end of the experiment as two statistics post-performance tests. Each test comprised of two parts, the first part consists of objective questions which were based on understanding of statistics concepts. This part of the two tests measured students' conceptual knowledge. The second part of the test consists of subjective questions whereby students were required to solve the statistics problems using the appropriate statistical analyses and demonstrating the correct procedures. This part of the two tests measured students' procedural knowledge.

1.7.7 Conceptual Knowledge

Hiebert and Lefevre (1986) defined conceptual knowledge as relationship between pieces of information and it is achieved by creation of relationships between existing knowledge and new information. In this study, students' conceptual knowledge refers to students' ability to answer correctly to the first part of the statistics tests which consist of objective questions which measures understanding of statistics concepts. Students' conceptual knowledge was measured based on the total correct answers obtained from the objective questions of Statistics Test I and Statistics Test II.

1.7.8 Procedural Knowledge

Kumar and Kogut (2006) explained procedural knowledge as being the procedural representation of knowledge. According to Hiebert and Lefevre (1986) procedural knowledge in mathematics is identified as a sequential set of procedures to obtain the correct solutions to the problems. They stated that procedural knowledge includes knowing the formal language, knowing algorithms and rules for completing tasks and procedures, and knowing strategies for solving problems. In this research, procedural knowledge is defined as the ability of students to demonstrate the correct steps and procedures of appropriate statistical analyses in solving the subjective statistics problems. The students' procedural knowledge was measured based on the total scores obtained from the subjective questions of Statistics Test I and Statistics Test II.

1.7.9 Mental Load

Mental load refers to the total amount of controlled cognitive processing in which a subject is engaged during any problem solving task (Paas & van Merrienboer, 1993). Measures of mental load can provide information on the cognitive costs of learning, performance, or both. Paas, Tuovinen, Tabbers and van Gerven (2003) state that mental load can be considered as the means of reflecting the actual cognitive load and can be measured using the nine-point symmetrical rating scale, ranging from very low mental load (1) to very, very high mental load (9). This rating scale is called the Paas Mental Effort Rating scale (PMER), designed by Paas and van Merrienboer (1994) to measure students' mental load. This technique is based on the assumption that people are able to introspect their cognitive processes and report the amount of mental effort spent (Paas, Renkl & Sweller, 2003). It has been demonstrated that people are quite capable of giving a numerical indication of their perceived mental burden (Gopher & Braune, 1984, cited in Paas et al. 2003).

In this study, mental load implies the perceived amount of mental load which a student spends while solving statistic assessment problems during the process of learning. Mental load is measured by the nine-point rating scale with 1 indicating very, very low effort and 9 indicating very, very high effort incurred during solving each assessment problems given. For each assessment problem, students were asked to report the amount of mental load invested on the nine-point symmetrical category scale presented below the questions (Appendix E).

1.7.10 Instructional Efficiency

Instructional efficiency is the combination of mental load invested in the learning phase and test performance which was designed by Paas and Merrienboer (1993). Instructional efficiency is a diagnostic instrument to identify and differentiate the efficiency of instructional modes. The instructional efficiency is measured based on performance in the test and the mental load invested in the learning phase. The mean standardized test performance (P) and the mean standardized mental load during the learning process (E) scores attained by learners in a certain condition are entered into the following formula:

$$\mathbf{Efficiency} = \frac{\mathbf{zP_{test} - zE_{learning}}}{\sqrt{\mathbf{2}}}$$

In this study, instructional efficiency of each approach (PBL-Tr, PBL-Web, Conv) is calculated by obtaining the mean overall test performance scores for each instructional approach and the mean mental load incurred during solving assessment problems (students rating of each problem solving task using the PMER scale). The two scores were substituted in the above formula to obtain the instructional efficiency score or index.

1.7.11 Total Number of Errors

Errors performed in any problem solving activity or task can be quantified by examining the solution set produced by the learners (Tarmizi & Sweller, 1988). It also refers to discrepancy between the learners' solution set and the correct solution scheme. In this study, the total number of errors for each student refers to the total number of mistakes made in answering the subjective questions of Statistics Test I and Statistics Test II. The number of errors of each test was computed based on summation of the number of errors which students obtained in solving each of the subjective problems of the test (Appendix F).

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