THE EFFECTS OF PBL ON UNDERSTANDING OF THERMODYNAMICS, GROUP WORK AND SELF-DIRECTED LEARNING SKILLS AMONG PHYSICS UNDERGRADUATES

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by

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KESAN PBM KE ATAS KEFAHAMAN TERMODINAMIK, KEMAHIRAN KERJA BERKUMPULAN DAN PEMBELAJARAN TERARAH- KENDIRI DALAM KALANGAN PELAJAR IJAZAH PERTAMA FIZIK

ABSTRAK

Tujuan kajian ini adalah untuk membandingkan kesan daripada tiga kaedah: pembelajaran berasaskan masalah (PBM), PBM dengan kacdah kuliah, dan pengajaran konvensional ke atas kefahaman termodinamik, kemahiran kerja berkumpulan dan pembelajaran terarah-kendiri dalam kalangan pelajar ijazah pertama fizik. Saiz sampel sebenar terdiri daripada 122 orang pelajar, yang dipilih secara rawak daripada Jabatan Fizik, Kolej Pendidikan di Iraq, bagi tahun akademik 2011-2012. Dalam kajian ini, ujian pra dan pasca dijalankan dan instrumen ditadbirkan kepada pelajar bagi pengumpulan data. Bagi tujuan menganalisis data, statistik inferens digunakan. Pemboleh ubah bebas adalah PBM, PBM dengan kaedah kuliah, dan pengajaran konvensional. Pemboleh ubah bersandar pula adalah skor pasca ujian kefahaman topik termodinamik, kemahiran kerja berkumpulan, dan kemahiran pembelajaran terarah-kendiri. Kovariat bagi analisis statistik adalah skor praujian bagi kefahaman topik termodinamik, kemahiran kerja berkumpulan, dan kemahiran pembelajaran-kendiri. Data dianalisis dengan menggunakan SPSS/ (*Statistical Package Social Sciences*) versi 19. Secara keseluruhan, keputusan statistik bagi semua hipotesis nul ditolak. Justeru, penggunaan PBM dengan kaedah kuliah mampu meningkatkan kefahaman topik termodinamik dengan lebih baik berbanding dengan penggunaan PBM sahaja atau penggunaan kaedah pengajaran konvensional. Namun demikian, penggunaan PBM tanpa atau dengan kaedah kuliah berupaya meningkatkan kemahiran kerja berkumpulan, dan pembelajaran terarah-kendiri dengan lebih baik berbanding dengan kaedah pengajaran konvensional.

THE EFFECTS OF PBL ON UNDERSTANDING OF THERMODYNAMICS, GROUP WORK AND SELF-DIRECTED LEARNING SKILLS AMONG PHYSICS UNDERGRADUATES

ABSTRACT

The aim of this study is to compare the effects of three methods: problem-based learning (PBL), PBL with lecture method, and conventional teaching on the understanding of thermodynamics, group work and self-directed learning skills among physics undergraduates. The actual sample size comprises of 122 students, who were selected randomly from the Physics Department, College of Education in Iraq, for academic year 2011-2012. In this study, the pre and posttest were done and the instruments were administered to the students for data collection. Inferential statistics were employed to analyze data. The independent variables were the PBL, the PBL with lecture method, and the conventional teaching. Dependent variables of statistical analysis were posttest scores on the understanding of thermodynamics, group work skills, and self-directed learning skills. Covariates of statistical analysis were pretest scores of the understanding of thermodynamics, group work skills, and self-directed learning skills. The data were analyzed using statistical package social sciences (SPSS) version 19. Overall, the statistical results rejected all null hypotheses of this study. Thus, the use of PBL with lecture method enhances the understanding of thermodynamics better than using the PBL alone or using conventional teaching method. Using the PBL without or with lecture method promotes the skills of group work, and self-directed learning better than using the conventional teaching, among physics undergraduate.

CHAPTER ONE

INTRODUCTION

1.1 Overview

This chapter presents the research background, problem statement, objectives of the study, research questions, and research hypotheses. It also explains the significance of the study, theoretical framework and limitations of the study. The chapter concludes with the operational definitions and chapter summary.

1.2 Background

The most important requirement to reach the upper stages of science teaching is to internalize and understand the science concepts (Kavsut, 2010). Science and its applications are part of daily life to make our life better and therefore the development of an individual's understanding of science and its applications is one of the objectives of science instruction (Adiguzel, 2006). In the modern era, most countries have shown increasing interest in teaching and learning science and they expend efforts to develop science education (Kavsut, 2010; Ozmen, 2004). Science education is needful in every phase of life and is strongly related to the active notion of teaching science (Aydogan, Gunes, & Gulçiçek, 2003; Kavsut, 2010). Mere concepts in science and scientific natural events may lead students to incorrect interpretations and alternative opinions not accepted by scientists (Amir & Tamir, 1994; Champagne, Gunstone, & Klopfer 1983; Treagust, 1988). As a result, most students think that science course is difficult particularly owing to the difficulty in understanding physics concepts, as the explanations differ from scientific perspective and prohibit the significance of learning science (Keles & Demirel, 2010). Sometimes, the textbook is part of the problem and is one of the reasons leading to the difficulty in understanding physics concepts (Kavsut, 2010).

Rapidly changing recent science applications require science education students to acquire lifelong skills such as group work and self-directed learning skills, which are part of the ability to respond to advances in science. Moreover, the teaching of science and understanding of its concepts become important more than ever (Montero & Gonzalez, 2009; Sahin, 2010b). In science education, teachers and students who have creative and critical thinking skills and problem-solving abilities have a sound conceptual understanding of basic sciences including physics (Sahin, 2010b). According to Rascoe (2010), conceptually understanding science involves use of new strategies by teachers and students to represent and re-present science concepts. The sound step toward improving the teaching of science is by making students understand science concepts (Bouwma-Gearhart, Stewart, & Brown, 2009; Cakir Olgun, 2008; Miller, Streveler, Yang, & Santiago Roman, 2009).

Literature on physics education has shown that students have numerous difficulties in understanding physics concepts in almost all topics of physics (e.g., Gonen & Kocakaya, 2010; Maloney, O'kuma, & Hieggelke, 2001; Martin-Blas, Seidel, & Serrano-Fernández, 2010), and particularly in the concepts of thermodynamics (e.g., Miller, Streveler, Yang, & Santiago Roman, 2009; Nottis, Prince, & Vigeant, 2010; Rascoe, 2010). Understanding the distinctions among heat, energy, and temperature in physics can be difficult for students at all levels of instruction, including those in science education. Difficulties of understanding the physics concepts on heat transfer continue even after students successfully complete relevant coursework (Nottis, Prince, & Vigeant, 2010). Science students in introductory level often have difficulty distinguishing between thermal physics concepts (Carlton, 2000).

Viennot (1991), “thermodynamics is a subject that involves multivariable problems and obvious difficulties” (p. 3). Understanding the distinctions among heat, energy, and temperature in physics can be difficult for students at all levels of education. Troubles in understanding thermodynamics can continue even after students successfully complete their coursework (Nottis, Prince, & Vigeant, 2010; Self, Miller, Kean, Moore, Ogletree, & Schreiber, 2008). There are certain misconceptions of thermodynamics that students may hold; for instance, they often believe that heat and cold are distinct substances as opposed to energy. They may also believe that cold is transferred from one object to the next owing to their experience with coolers and refrigerators (Halverson, Freyermuth, Siegel & Clark, 2010; Usta & Ayas, 2010).

The students must have insufficient prior knowledge to understand the problem deeply (Norman & Schmidt, 1992). Activation of prior knowledge allows students to form a basic framework where new knowledge is added. If learning is an effective procedure and constructs on prior information, this can likely lead to successful storage of recent knowledge. Prior knowledge needs to be activated to know recent knowledge, as well as to build on new knowledge, which is useful in the future professional life of the student (Xiuping, 2002). Researchers have described the relative effectiveness of different pedagogical approach in helping students understand physics concepts, such as heat, energy, and temperature. They encourage removing the difficulties of understanding physics concepts among students through their identification and through development of strategies which supply learners with exact and conceptual knowledge needed for solving problems in physics. Gonen and Kocakaya (2010) report that students may be enabled to address difficulties of concepts and understand thermodynamics concepts, by developing approaches and strategies that centre on certain concepts. PBL achieves the constructivism idea by building on previous knowledge skills and constructing on present cognitive frameworks which is advantageous in future professional life (Xiuping, 2002). Based on the literature, one of the most effective approaches in addressing these difficulties is to understand the physics concepts is problem-based learning (PBL), which is a scientifically accurate model (Bouwma-Gearhart, Stewart, & Brown, 2009; Cakir Olgun, 2008; Miller, Streveler, Yang, & Santiago Roman, 2009). It is more efficient than traditional science teaching method.

PBL enhances a set of pedagogical results such as skills of self-directed learning and group work (Neild, 2004). According to Hmelo-Silver (2004), PBL as a teaching method, is based on student-centered learning, where students learn through simplified problem solving and where problems should be complex, ill-structured, and real. Students work in cooperative groups and participate in self-directed learning for solving problems. In PBL, students work together in a group to attain objectives; as collaboration, interaction, communication, and discussion. PBL allows the development of students' group work skills. Therefore, students collaborate to work cooperatively with others in a team and assume responsibility for their own learning. PBL also allows students to search information from any subject, allowing them to understand science concepts (Ball & Pelco, 2006; Cheong, 2008). Group work allows the team to learn to work together to determine the logistics of the problem at hand and utilize higher order thinking skills (Holter, 1994), incoming broad assortment of resource and learners' experiences and develop respect for various opinions (Williams, 2001). The constructive social aspect of PBL is very important; cooperation has been demonstrated to lead to more effective problem solving than competitive learning (Qin, Johnson, & Johnson, 1995). PBL is a student-centred teaching approach that enables students to become active participants in solving problems, answering questions, cooperating in learning, working in teams on problems or projects, and taking on more of the responsibility for learning (Ates & Eryilmaz, 2011).

To address and overcome the aforementioned problems and challenges on difficulties of understanding the abstract thermodynamics concepts, the researcher proposes this study of using PBL to enable students to understand thermodynamics. Moreover, there are several reasons for using PBL in the current study. One of these is the weakness of the traditional science teaching method, under which the traditional teacher-centred learning assumes that all learners take in recent material in a like speed and have like degree of knowledge in the topic being taught. A teacher guides the students and offers them new information. The focus of teaching is on the transmission of knowledge from the expert teacher to the novice learner (Cheong, 2008). Under the conventional manner, students listen and watch, and most teaching time is spent with the instructor lecturing. To enable understanding of the content, students are required to individually work on tasks, and collaboration is encouraged. In the traditional method, a teacher is required to have or to learn effective writing and speaking skills. Mostly, under traditional experiments of science, students have conceptions on what the findings will be, or what they anticipate it to be, and the student tries to emphasize on this (Azu & Osinubi, 2011; Cheong, 2008).

The PBL environment establishes the relevance between the knowledge and its use. The interaction between the problem and use of knowledge fosters a deeper understanding of the content knowledge (Ball & Pelco, 2006). The problems used are real-life situations that they may face in the future and are educationally sound. Problems with "ill-structured feature help students learn a set of important concepts" (Gallagher, 1997, p. 338). Instructors in PBL are more creative with their teaching while old methods, which are based on boring lectures and memorization of material, are challenged with this delivery method (Ates & Eryilmaz, 2011; Sulaiman, 2011).

According to McParland, Noble and Livingston (2004), the PBL curriculum is significantly more successful than the previous, traditional course (p. 859). Tang (2008) pointed out that PBL is accepted by most students and teachers as a teaching method, and is believed to improve understanding ability. In PBL, student-centred learning method shifts the concentration of effectiveness from the instructor to the students to reduce teacher-centred learning. Unlike the traditional teaching method, PBL enables student-centred teaching approaches, resulting in active participation of students in solving problems, answering questions, engaging in cooperative learning, working in groups on problems, and taking on more responsibility for learning (Ates & Eryilmaz, 2011; Ball & Pelco, 2006; Cheong, 2008; Subramaniam, Scally, & Gibson, 2004). Lycke, Grottum and Stromso (2006) demonstrated that PBL students showed "significantly more self-regulated learning and they perceived themselves as more active contributors to group learning process and used a broader range of resources than students in the traditional programme" (p. 113). Ates and Eryilmaz (2011) asserted that student-centred learning allows depth of understanding of material, acquisition of new materials and creative skills such as problem-solving, group work, and self-directed learning, among students. Evidently, it is superior to the traditional teacher-centred instruction.

Students acquire group work skills and self-directed learning skills through PBL. There are several advantages of using group work skills. According to Lambros (2004) this group skills development is facilitated in the following way; "to deliver the problems, first divide the class into small groups of four to six students" (p. 16). The skills of group work are important to shift the responsibility of learning from the instructor to the student. The shift occurs in an environment of cooperative learning of group work (Cooper, Sloan, & Williams 1988; Halpern, 2000).

Moreover, educators cannot teach students everything to accommodate the extra knowledge. Also, teaching today's facts which are important today may seem less important tomorrow. Given this, students need to have the necessary skills for lifelong learning that help them to access information, analyze problems, and evaluate outcomes and those who are able to develop such skills will be ready for learning in the present and future (Chakravarthi & Vijayan, 2010; Shokar, Shokar, Romero, & Bulik, 2002). Students have opportunities to evaluate their understanding of study materials with others team members through social interaction. All these facilitate the students' knowledge of contents. It encourages greater understanding, thereby revealing difficulties of understanding the physics concepts in light of teaching and learning, curriculum, science instruction, and content-level understanding by learners (Sellitto, 2011; Whitcombe, 2013). Education research indicates that, using group work skills is one of the most effective and invaluable teaching tools that can help students to increase learning and retention of what is taught for a long time, acquiring many different ideas on a subject and academic background, and finally, preparing them for project work in a professional environment as PBL (Abdelkhalek, Hussein, Gibbs, & Hamdy, 2010).

According to Seymour (2013), PBL, as an appropriate teaching mode, has a favourable influence on the progress of the team-working skills of students. These skills are important for graduates to master and enable effective collaborative working. Some studies revealed that students learning under a PBL method possess improved ability to enhance work in teams (Antephol, Domeij, Forsberg, & Ludvigsson, 2003; Grady, Gouldsborough, Sheader, & Speake, 2009; Reeves, Summerfield Mann, Caunce, Beecraft, Living, & Conway, 2004). These studies suggest positive outcomes in terms of team working skills. The terms 'teams' and 'groups' are overwhelmingly used interchangeably within the literature but PBL literature prefers the term 'group' (Baptiste, 2003; Barrows & Tamblyn, 1980; Savin-Baden 2000).

Levi (2010) defined the term ‘team’ as a special type of group where people work interdependently to achieve a goal. Group work or team assignments are just one strategy of cooperative learning that enables students to become actively engaged in their academic pursuits within that course (Holter, 1994; Payne, Monk-Turner, Smith, & Sumter, 2006). Extensive researches have been conducted on the benefits accrued through cooperative learning experience like group work (Colbeck, Campbell, & Bjorklund, 2000; Cooper, Prescott, Cook, Smith, Mueck, & Cuseo, 1990; Cottell & Millis, 1993; Haberyan, 2007; Halpern, 2000; Hassanien, 2007; Kreie, Headrick, & Steiner, 2007). In PBL, learners are encouraged to take the initiative for their own knowledge (Lee, Mann, & Frank, 2010). There are evidences in support of PBL which seemingly have a superior effect on fostering self-directed learning skills, compared with conventional curricula (Evans, 2009; Koh Khoo, Wong, & Koh, 2008). PBL is a method of arranging education which lets students to take responsibility, foster, enhance, and develop self-directed learning skills (McParland, Noble, & Livingston, 2004; Suh, 2005; Sundbladi, Sigrell, John, & Lindkvist 2002).

Blumberg (2000) suggested that PBL students employ deep-level study strategies such as use library, and continuing to develop their self-directed learning skills. PBL environment can provide opportunities for students to develop their skills of self-directed learning which will help them to manage in designing, performance, and evaluating learning outcomes (Thornton, 2010). The skills of self-directed learning have been defined as the important and most essential skills for students to attain new knowledge easily and perfectly (Harvey, Rothman, & Frecker, 2003). Through self-directed learning which is a crucial skills, students can control what they want to learn, how they want to learn and when they want to learn, individuals take the initiative and significant responsibility for learning with or without the help of others. Under self-directed learning skills, students as individuals, select and manage their learning activities and this enables them to set objectives, question, inquire and solve problems, define what is worthwhile to learn, select suitable resource, gather facts on their achievement based on feedback and self-observation, and use data which help them in a life-long learning process, evaluate their present performance and learning outcomes. Thereby, the learner will be more concerned in knowledge and supply base for skills that can simplify additional knowledge, and this helps students to learn more and learn better (Abraham, Fisher, Kamath, Izzati, Nabila, & Atikah, 2011; Chakravarthi & Vijayan, 2010; Dynan, Cate, & Rhee, 2008; Knowles, 1975; Lee, Mann, & Frank, 2010).

Under skills of self-directed learning, students can run the planning, conceptualization, conduct and evaluation of learning (Brookfield, 2009). Self-directed learning is present in learning situations, and variety of actions including reading, cooperation, debate, accessing resources, research, and development. Using the time to prepare their course and studying in-depth are expected from students in self-directed learning (Deepwell & Malik, 2008). Self-directed learning means neither distance learning nor isolated learning at home, in the library, or in the office. Rather, it is as a mode of learning in which the individual needs to look for suitable education resources, directs the education process, and evaluates the outcomes irrespective of the place or distance (Park & Kwon, 2004). Actually, in self-directed learning, whole procedures on what and how to learn depend on the student. In the skills of a self-directed learning, possibility exists that some periods arise when a learner decides to be most effective when tentatively under the guidance of an expert (Brookfield, 2009). According to Tsay, Morgan and Quick (2000), self-directed learning consists of some aspects, such as active learning, passion for learning, learning motives, independent learning, nosy nature, and taking responsibility for learning. In self-directed learning, the teacher is the one who guides and controls the learning process (Bev, 2001). Self-direction in learning is a procedure of the inner features of the student and the outer features of a didactic procedure (Bev, 2001; Brockett & Heimstra, 1991). Self-directed learning therefore reaches back to a situation of psyche and depends on some of abilities and attitudes like the ability to learn independently, self-punctuality, and curiosity (Park & Kwon, 2004).

Hanna, Glowacki-Dudka and Conceicao-Runlee (2000) argued that for educational success, learners should have self-directed learning skills as this type of learning lets learners continue learning on their own initiative. Consequently, self-directed learning means an ability to sub-edit education objectives, name resource, select and carry out proper education strategy, and evaluate instruction outcome as well as learning experiences. In addition, under self-directed learning, a person takes the primary responsibility and initiative for planning and diagnosing his/her learning requirements (Deepwell & Malikb, 2008; Tsay, Morgan, & Quick, 2000). The aim of the current study is to investigate the effects of PBL without or with lecture method compared with conventional teaching method on the understanding of thermodynamics, group work and self-directed learning skills among physics undergraduates.

1.3 Problem Statement

Several educational studies focus on the difficulties and troubles confronted by science students that inhibit the understanding of science concepts (Baser, 2006; Bouwma-Gearhart, Stewart, & Brown, 2009; Cahyadi & Butler, 2004; Cakir Olgun, 2008; Polanco, Calderón, & Delgado, 2004; Posner, Strike, Hewson, & Gertzog, 1982; Rascoe, 2010; Savinainen, Scott, & Viiri, 2004; Schmidt, Marohn, & Harrison, 2007; Thijs & Dekkers, 1998; Usta & Ayas, 2010).

The difficult and hardly understandable concepts can generate new concepts which are contradictory to the accepted concepts in scientific societies, and may be differently structured and settled in the minds of students, who generally resist change (Amir & Tamir, 1994; Andersson, 1986; Canpolat, Pinarbasi, Bayrakceken, & Geban, 2004; Cepni, Tas, & Kose, 2006; Usta & Ayas, 2010). Science students come to science lectures with a pre-existing knowledge of science concepts, which are usually inconsistent or are merely partially consistent with the actual scientific view, and these lead to difficulty in understanding the science concepts particularly in physics (e.g., Baser, 2006; Cepni, Tas, & Kose, 2006; Gonen & Kocakaya, 2010; Kavsut, 2010; Martin-Blas, Seidel, & Serrano-Fernández, 2010). This difficulty negatively affects the students' next stage of learning (Canpolat, Pinarbasi, Bayrakceken, & Geban, 2004; Cepni, Tas, & Kose, 2006; Martin-Blas, Seidel, & Serrano-Fernández, 2010; Usta & Ayas, 2010). More importantly, many of these difficulties in understanding physics concepts are widespread and have a detrimental effect on problem solving (Brown, 1992; Champagne, Gunstone, & Klopfer, 1982). Many of these constructs of science concepts lead students to formulate incorrect schema about the nature of concepts in science, including physics (Slykhius, 2005). Teaching methods can play important role for helping students to understand physics material including concepts. Under conventional teaching, physics undergraduate confront difficulties to understand physics material in all topics of physics, particularly thermodynamics (Gonen & Kocakaya, 2010; Nottis, Prince, & Vigeant, 2010; Rascoe, 2010; Usta & Ayas, 2010). Also, the conventional teaching failed to prepare students for solving problems and answering questions of thermodynamics, and unsuccessful to develop their lifelong skills (Hung, Jonassen, & Liu, 2008). The lack of skills like group work skills and self-directed learning skills can lead to problems of understanding of physics concepts among students that prevent student-centred learning, acquisition of new materials, solving problems, and evaluating their learing and understanding of materials. Consequently, the lack of aforementioned skills will restrict to access information, analyze problems, take the initiative for their own knowledge, and evaluate outcomes (Abraham, Fisher, Kamath, Izzati, Nabila, & Atikah, 2011; Ates & Eryilmaz, 2011; Chakravarthi & Vijayan, 2010; Lee, Mann, & Frank, 2010).

Actually, problem-based learning (PBL) is one of the most successful methods, which promotes deep understanding (Ball & Pelco, 2006; Prince, 2004; Sahin, 2009a; Tang, 2008; van Berkel & Schmidt, 2005). Findings of prior studies support PBL, which offers students opportunities to develop skills such as group work, and self-directed learning for solving problems (Bell, 2012; Downing, Ning, & Shin, 2011; Reeves, Summerfield Mann, Caunce, Beecraft, Living, & Conway, 2004; Whitcombe, 2013). Whereas, PBL allows the development of the group work and self-directed learning skills, thus making students work cooperatively in a team and assume individual responsibility for learning. The PBL allows learners to pursue information from any subject, and this allows them to deeply understand science concepts (Ates & Eryilmaz, 2011; Ball & Pelco, 2006; Cheong, 2008; Subramaniam, Scally, & Gibson, 2004).

However, using the PBL alone and adopting it only as a teaching method is considered risky because it entails complete shift from one of the teacher-centred learning in conventional teaching to another of the student-centred learning in the PBL. Thus, incorporating PBL into another method through an intelligent combination of using both the PBL and lecture method for teaching thermodynamics which can provide positive influence on the learning process and most effective training for bachelor's degree physics students (Darnton, Lucas, & Pearson, 2007; Liceaga, Ballard & Skura, 2011; Saalu, Abraham & Aina, 2010). Based on aforementioned, the researcher adopts a teaching method which is the PBL with lecture method. In the current study, five problems for PBL were developed in the topic of thermodynamics in the field of physics to investigate the understanding of thermodynamics, group work and self-directed learning skills among physics undergraduates.

1.4 Objectives of the Study

The main objective of this study is as follows:

$O_{1:}$ To compare the effects of using problem-based learning (PBL), the PBL with lecture method, and the conventional teaching on understanding of thermodynamics, group work and self-directed learning skills among physics undergraduates.

Specifically, the sub-objectives of this study are as follows:

$O_{1a:}$ To compare the effects of using PBL, the PBL with lecture method, and the conventional teaching on understanding of thermodynamics among physics undergraduates.

$O_{1b:}$ To compare the effects of using PBL, the PBL with lecture method, and the conventional teaching on group work skills among physics undergraduates.

$O_{1c:}$ To compare the effects of using PBL, the PBL with lecture method, and the conventional teaching on self-directed learning skills among physics undergraduates.

1.4.1 Research Questions

The main question of this study is as follows:

$Q_{1:}$ Are there significant differences on the linear combination of posttest mean scores of understanding of thermodynamics, group work skills and self-directed learning skills among physics undergraduates who followed PBL, the PBL with lecture method, and the conventional teaching after the effect of mean scores of pretest is controlled?

Specifically, the sub questions of this study are as follows:

Q_{1a}: Are there significant differences on posttest mean scores of understanding of thermodynamics among physics undergraduates who followed PBL, the PBL with lecture method, and the conventional teaching after the effect of pretest mean scores is controlled?

Q_{1b}: Are there significant differences on posttest mean scores of group work skills among physics undergraduates who followed PBL, the PBL with lecture method, and the conventional teaching after the effect of pretest mean scores is controlled?

Q_{1c}: Are there significant differences on posttest mean scores of self-directed learning skills among physics undergraduates who followed PBL, the PBL with lecture method, and the conventional teaching after the effect of pretest mean scores is controlled?

1.4.2 Research Hypotheses

The main hypothesis of this study is as follows:

H_{01}: There are no significant differences on the linear combination of posttest mean scores of understanding of thermodynamics, group and self-directed learning skills among physics undergraduates who followed PBL, the PBL with lecture method, and the conventional teaching after the effect of pretest mean scores is controlled.

Specifically, the sub hypotheses of this study are as follows:

H_{01a}: There are no significant differences on posttest mean scores of understanding of thermodynamics among physics undergraduates who followed PBL, the PBL with lecture method, and the conventional teaching after the effect of pretest mean scores is controlled.

H_{01b}: There are no significant differences on posttest mean scores of group work skills among physics undergraduates who followed PBL, the PBL with lecture method, and the conventional teaching after the effect of pretest mean scores is controlled.

H_{01c}: There are no significant differences on posttest mean scores of self-directed learning skills among physics undergraduates who followed PBL, the PBL with lecture method, and the conventional teaching after the effect of pretest mean scores is controlled.

1.5 Significance of the Study

In this study, students are encouraged to be active rather than passive and cooperate rather than compete, through enhancing deep understanding of thermodynamics and promoting skills of group work and self-directed learning (Cheong, 2008). So, students become more proficient for example, answering questions and solving problems of thermodynamics, working in groups effectively, carrying out tasks cooperatively, accessing different resources, and identifying appropriate knowledge (Sungur, Tekkaya & Geban. 2006).

The findings of present study encourage physics teachers to adopt alternative method like PBL without/ with lecture method rather than conventional method to attain educational objectives. They became more creative with their teaching, in contrast with traditional method (Ates & Eryilmaz, 2011; Sulaiman, 2011). Thus, the role of physics teachers is as facilitators, as coordinators of activities, and as evaluators (Sungur, Tekkaya & Geban. 2006).

For further studies, researchers can adopt or adapt the research instruments, and benefit of the developing problems of the current study. As well as, present study can benefit of it to carry out further researchers in other topics like Mechanic, Electricity, Mechanic and Nuclear physics, or in other field like biology, chemical, and Mathematic. The findings of this study supports current theories like constructivist theory which is base of PBL, social constructivist theory which is base of the group work skills, and information processing theory which is base of the self-directed learning skills.

1.6 Theoretical Framework

The theoretical basis of PBL is the constructivist theory which postulates that students create knowledge through activity and experiences of learning. Knowledge is socially created through planned interactions and collaboration in group work entailing the carrying out of meaningful tasks (Ishii, 2003; Koch, 2005; Saxe, Gearhart, Shaughnessy, Earnest, Cremer, Sitabkhan, Platas, & Young, 2009). Knowledge is constructed by persons through environmental interactions with them and engagement in investigations, communication or group activities where new knowledge is created by building on current knowledge

(Hernandez-Ramos & Paz, 2010). Learning happens as a result of discussions on the basis of evidence, driven by the socio-cultural context and the development of personal information (Simsek, 2004). Because knowledge is socially negotiated, learning activities should encourage collaboration to provide students with opportunities to test their ideas against those of their classmates. This process is one of the principles that govern the design of PBL based on the constructivist notion of cognition (Savery & Duffy, 1995). The PBL method is one of the important approaches used in the constructivist perspective. It is primarily underpinned by the constructivist learning principles, encouraging learner-centered engagement with content, and learner interaction with their classmates as the core to the process linked with learning the way to practice theoretical knowledge in professional scenarios (Edwards & Hammer, 2004).

Furthermore, the PBL is considered by Savery & Duffy (1995) as the best example of a constructivist learning environment. The constructivist theory is the foundation of PBL where it assumes that knowledge is developed by learners while attempting to make sense of their experiences (Driscoll, 2000). PBL achieves the ideal of constructivism as it activates previous knowledge, and builds on present cognitive frameworks that are useful in future professional life (Xiuping, 2002). Constructivism learning perspective focuses on the way learners create an understanding of the world and implicit to this is the fact that meaning and understanding are both developed in a process that hinges on the specific knowledge bases and cognitive operations of every individual. The learner's personal knowledge constructs filters experience and assimilates it into their conceptual frameworks (Thurley & Dennick, 2008). Triggering previous knowledge is important in this process as it enables students to connect novel information with extant knowledge (Dolmans, Wolfhagen, van der Vleuten, & Schmidt, 1997). The students may modify their prior learned beliefs through the process. The constructivist learning model also emphasizes the significance of social and interpersonal factors in assisting learning (Savery & Duffy, 1995). The model's stress on activation and building upon previous knowledge is made in light of learning and encouragement of learners (Loyens, Rikers & Schmidt, 2006).

Moreover, information processing theory has also been contended to be the basis of PBL with its three main components closely linked with the constructivist perspective (Albanese, 2000). Hence, PBL entails in-depth learning through the transformation of experience and comprehension of processes and interactions as opposed to surface learning of facts (O'Neill, Willis, & Jones, 2002). Furthermore, the constructivist model of learning emphasizes the significance of social and interpersonal factors in the facilitation of learning (Savery & Duffy, 1995).

Advocate of social constructivist theory including Dewey (1989) and Vygotsky (1978) contend that individuals learn best not through the assimilation of what they are told but through their knowledge-construction process with their peers. The process should be modeled and reinforced in the community and environment in order for individuals to learn to create knowledge (Jonassen, 1999; Nelson, 1999). More importantly, PBL characteristics are consistent with constructivist theory (Suh, 2005). Social constructivist refers to various cognitive constructivism emphasizing on the cooperation of learning. The theory stresses on the importance of both culture and context in understanding the phenomena in society and development knowledge on the basis of this understanding (Derry, 1999, McMahon, 1997). The pioneering founder of social constructivist theory, Vygotsky, claims that social interaction is an important part of learning (Powell & Kalina, 2009). Vygotsky (1978) argues that "all cognitive functions originate in, and must therefore be explained as products of social interactions and that learning was not simply the assimilation and accommodation of new knowledge by learners; it was the process by which learners were integrated into a knowledge community" (p. 57). Social constructivist learning has its basis on the student's social interactions in the classroom coupled with personal critical thinking process. Some of the theories brought forward by Vygotsky are involved in social constructivist like social interaction, inner speech and culture (Powell & Kalina, 2009; Vygotsky, 1962).

Cooperative learning is part of creating the social constructivist theory, so a social constructivist lecture hall requires students to develop skills of group work and to view individual learning as significantly linked to the group's learning success (Powell & Kalina, 2009). Students are not only discouraged to work with teachers but encouraged also to work with other students as a group. Students have many things to offer one another, and at the same time they hold the responsibility of researching the theme and presenting their findings. When students master the completion of their projects or activities in a group, the internalization of knowledge occurs in each individual at a different rate based on student's experience. According to Vygotsky's perspective, internalization occurs more effectively when there is social interaction (Powell & Kalina, 2009). Additionally, different perspectives given for a certain material can offer new and exciting opportunities for a student and the presentation of specific concepts can facilitate discussions, problems when guided by directed questions, introduction and clarification of concepts and information and triggering prior learned material. Teachers can create work experiences for students to collaborate with each other for constructing cognitive or individual internalization of knowledge. Vygotsky firmly believes that social interaction and cultural influences have a huge impact upon the student and his/her learning. Before they can start learning the curriculum, it is pertinent that students understand themselves and their peers (Powell & Kalina, 2009).

Concerning, the information processing theory, this stems from the cognitive development theories (Anooshian, 1998). The theory has its basis on the perspective that the mind of an individual processes the information it obtains as opposed to just reacting to stimuli. This idea equates the mind to a computer, which is responsible for analyzing information (Gray, 2010). Reasoning is described in terms of methods in which information is processed by a computer. After the information is inputted, the computations initiates and information is outputted (Reyna & Brainerd, 1995). Hence, output depends on the input or it is interconnected with the input (Miller, 1956). Thus, reasoning will not take place in the absence of input–output correlation; the relationship between memory and reasoning is a thin one. Most information-processing explanations of reasoning revolve around the capacity limitations of short-term memory (Miller, 1956; Reyna & Brainerd, 1995). With the increase in input information, the transmitted information also increases. The problem in information processing is how to gauge the amount of transmitted information with the increase in input information (Miller, 1956). The information processing theory postulates that the mind possesses attention mechanisms, working memory and long-term memory. It addresses growth development in the ability of individual's brains to process and react to the received information (Gray, 2010). Theoretical basis of self-directed learning skills is the information processing theory. Figure 1.1 illustrates conceptual framework.

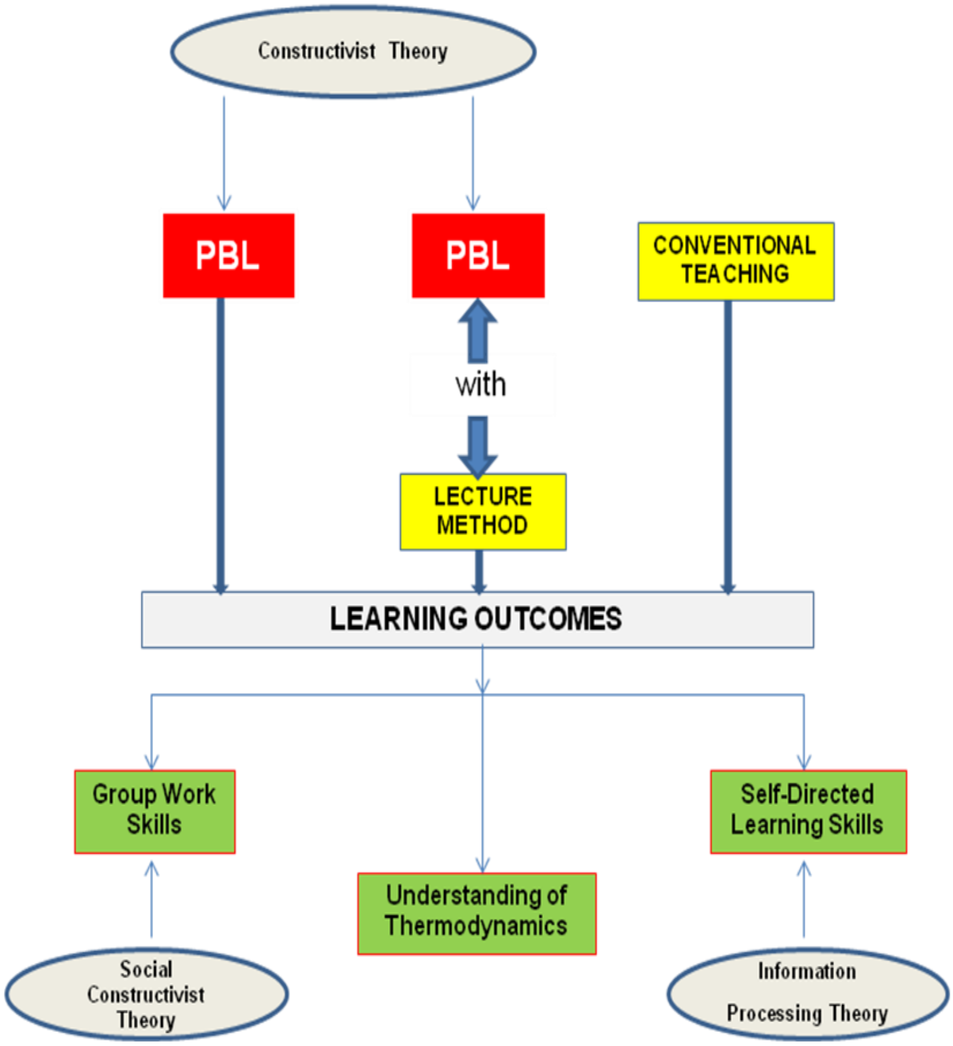

Figure 1.1: Conceptual framework

This theory postulates that students take responsibility of understanding their learning needs of information and knowledge where in which the mind inputs and process for planning, conducting, and evaluating learning experiences and for assessing the outcome value (Deepwell & Malikb, 2008; Tsay, Morgan & Quick, 2000).

1.7 Limitations of the Study

The present study has the following limitations:

1. The students sampled in the study consisted of students in Physics Department, College of Education, Iraq. Therefore, the findings may not be generalized to other departments or other college students.

2. The present study sample comprises of physics undergraduates. Therefore, the findings may not be extrapolated beyond the physics undergraduates to secondary level students.

3. The findings of the study may not be generalized to other science courses such as chemistry and biology.

4. The study is conducted in the context of student learning physics in Arabic language. The results may not apply to contexts in which students learn physics through a different language.

5. The group work skills and self-directed learning skills in this study are only indicated by group work skills and self-directed learning skills. The findings of this study may differ from studies utilizing other indicators.

1.8 Operational Definitions

The following are the operational definitions of the terms used in the study:

1. Problem-based learning (PBL)

PBL in this study is considered as instructional approach or teaching process based on the principle of using five problems, which are prepared by the researcher as the first step for obtaining fresh materials on thermodynamics among physics undergraduates. In PBL student-centered learning students take responsibility to