PROBLEM-BASED LEARNING EFFECTS IN 9TH GRADE BIOLOGY

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Chapter One

Introduction

The purpose of education has been a target of debate for many years with one claim being that education should "enable individuals to become effective problem solvers in their actual lives" (AAAS 1993, as cited in Akinoglu & Tandogan, 2007, p. 71). During their school years, students are exposed to countless amounts of information. It is expected that later in their life they will recall this information and decide how to use it. In the U.S., the curriculum offered to students follows the state and district requirements. Most of the courses available to high school students emphasize content knowledge and preparation for success on standardized tests. Regrettably standardized tests are the instruments used to evaluate students' progress. State agencies and school districts use them for accountability purposes. Higher-level skills such as applications, analysis, synthesis or even evaluation are often set aside or are in minimal practice in order to satisfy standardized test requirements. Unfortunately both content knowledge and the ability to take a multiple-choice test are not sufficient to be successful in life. Employers have requirements of their own such as working with others, field content knowledge, maybe technology efficiency and problem solving skills (Belland, Glazewski & Ertmer, 2009; Carrio, Larramona, Banos & Perez, 2011; Dunlap, 2005; Hung, Jonassen & Liu, 2008). Consequently, being able to solve problems or to seek a solution to a problem is a life skill that everyone should have. Life does not offer the option of four multiple choice answers; therefore students need to be exposed to open ended problems more probable in a real life situation. Problems can range from helping an unsatisfied customer; deciding how much of a product to order all the way to being able to invent a more efficient piece of machinery or technology keeping in mind safety or health issues. Problem solving requires commitment, ingenuity and time not always available in a classroom setting.

Problem

Students often have the ability to think critically if prompted by questions but appear not to be proficient with these skills on their own. Teachers need an instructional method that can help students acquire the skills needed in the workforce and for life in general. One recommendation is to use problem-based learning (PBL) as instructional strategy. PBL encourages students to think outside the box, to relate to real life situations and allows them to connect new materials to concrete concepts (Carrio, Larramona, Banos & Perez, 2011; Hung, Jonassen & Liu, 2008; Schmidt, Rotgans & Yews, 2011). Additionally, problem-based learning is a method that can be used to increase student content knowledge (Chin & Chia, 2004; Hung et al., 2008; Sungur & Tekkaya, 2006).

One advantage of PBL is that it allows students to use many skills and various ways to show what they learned (Belland et al., 2009; Sungur & Tekkaya, 2006). In PBL, students have the opportunity to work with others of different abilities, analyze what is needed to solve a problem and research for information to help accomplish the task (Schmidt et al., 2011; Dunlap, 2005). When confronted with a task, the students use the content they learned and take charge of what needs to be done (Kendler & Grove, 2004). They organize themselves and take various roles in order to accomplish the task in the most effective way (Belland et al. 2009).

Study and its significance

The purpose of the study is to compare the effects of problem-based learning with traditional teaching methods on 9th grade biology students. Although PBL has been researched, the study of the effects of PBL on content knowledge as exhibited on multiple-choice test in biology and the effects on different gender students have not been the targets of these research. This study will add to the overall understanding of the value of PBL as an instructional tool.

Questions

The specific questions that will be addressed are: (1) What is the difference in content knowledge as exhibited on a multiple-choice test (similar to state test) when academic biology students are exposed to two different teaching methods (traditional and PBL)? (2) How do male and female students compare with regard to content knowledge? (3) How do students' perceptions of learned skills between the two teaching methods differ?

Terms

For the purpose of this study, the following terms will be defined as they are below.

Problem-based learning: refers to the method that involves students trying to solve a problem and present their finding in a simulated real life situation.

Traditional learning: refers to the traditional teaching method with lectures, notes, worksheets and possibly labs.

Academic biology students/also referred as students: Students enrolled in a biology class not bound to enroll in an Advance Placement Biology class in their future.

Chapter 2

Review of the Literature

In order to have a more current understanding of problem-based learning (PBL), the review of the existing research outlines the history, criteria, benefits, and issues in problem-based learning. About twenty years ago, research focused heavily on gender differences, however today the numbers of research on this topic are smaller. The review on gender differences emphasizes distinctions in performances, attitudes, science topics, perceptions and practices.

Problem-based learning history

Problem-based learning (PBL) was first implemented in medical schools in the 1960’s in Canada (Azer, 2001; Colley, 2008; Kendler & Grove, 2004; Norman & Schmidt, 2001). The medical school at McMaster University began PBL because the faculty saw a disconnect between the ways medical students were being taught and the ways expert doctors actually practiced medicine. According to Barrows (as cited in Savery, 2006) “using a traditional lecture approach, did little to provide learners with a context for the content or for its clinical application” (p. 10). To remediate the problem, students were presented with medical cases and were asked to find solutions for their cases. Today PBL is put into practice in medical facilities all over the world (Akinoglu & Tandogan, 2007).

Over a period of years, PBL has been introduced into other subject areas and various levels of instruction (Azer, 2001; Hung, Jonassen & Liu, 2008). Gradually, PBL has been adapted in the fields of nursing, social work, engineering, architecture, law, optometry and management (Azer, 2001). Most recently, educational settings have included PBL as a strategy for engaging students in more authentic learning. However, to date many of the studies in K-12 educational setting were conducted with gifted and academic students (Belland, Glazewski & Ertmer, 2009).

Criteria for Problem-based learning

PBL is an instructional method that is characterized by providing students with the opportunity to learn through solving problems and reflecting on their experiences (Hmelo-Silver & Barrows, 2006). It is based in constructivist learning theory which refutes the transmission model of learning and stresses the active role of the learner. Barrows & Tamblyn (1980) argue that in professional practice, problem skills are more important than facts and that future employees are looking for collaborative problem-solvers.

In order for a lesson to be considered as PBL, it must adhere to certain criteria. The first criterion is that students must solve a simulated or real problem with multiple ways to approach the task (Savery, 2006), and "to provide a reasoned argument to support the solution they generate" (Hmelo-Silver & Barrows, 2006, p. 24). The problem-based method presents the students with the problem as the big picture. This large problem can be divided into simpler tasks or projects that will lead to the solution (Barron et al., 1998). “The initial situations lack all the information necessary to develop a solution”(Chin & Chia, 2004, p. 69) which requires the students to define the problem they are asked to solve (Sungur & Tekkaya, 2006).

A second criterion is that students must work in groups to assess what they know and define what they need to learn to address the problem (Chin & Chia, 2004). However students work independently to figure out specific aspects of the problem (Kendler & Grove, 2004). Students communicate and collaborate to solve the problem assigned. Each student reports to the group making sure everyone in the group learn from each other. Additionally, “each group member serves a role that counter balanced the shortcoming of other group members” (Belland et al., 2009, p. 14). In the process of searching for their answer students assess, analyze and use data from different sources (Sungur & Tekkaya, 2006).

In the third criterion for problem-based learning, the teacher is a guide or facilitator, not a lecturer (Akinoglu & Tandogan, 2007; Hmelo-Silver & Barrows, 2006). The teacher does not provide the correct answers to the students (Azer, 2001). The students become actively involved in the search for the solution. In the process they obtain a better understanding of the material leading to the solution (Hmelo-Silver & Barrows, 2006, p. 23; Schmidt, Rotgans & Yews, 2011 p. 796). The teacher takes the student's statement and gives the responsibility back to the student to clarify the meaning or even consider other views (Akinoglu & Tandogan, 2007; Hmelo-Silver & Barrows, 2006). The teacher has to be flexible to work with all the possible scenarios and questions the students develop. Hmelo-Silver and Barrows (2006) stress that "the teacher still leads the discussion, working towards global learning goals but choosing strategies on the fly" (p. 23). According to Hung, Jonassen & Liu (2008) and Hmelo-Silver & Barrows (2006), in order to help the process the teacher models the kinds of questions students need to be asking themselves. The process can be successful if the teacher can scaffold the material and techniques (Barron et al., 1998; Hmelo-Silver & Barrows, 2006; Savery 2006) and “revoice what students said in a way that helped them move forward” in the process (Hmelo-Silver & Barrow, 2006, p. 25). The teacher's presence and performance also influence the students' experience in the PBL method (Norman & Schmidt, 2001). The teacher is able to subtly influence the direction of the discussion, to change the flow of the discussion so students are not stopped in the process, and to get the students to see what aspects are important (Hmelo-Silver & Barrow, 2006). Progressively, the teacher begins to fade as the students take more responsibility for their own learning and begin to question each other in the way the teacher modeled (Hmelo-Silver & Barrows, 2006).

Another criterion is that the problem to be solved needs to be relevant and address real life situations that can possibly benefit the community (Hung et al., 2008; Savery, 2006). “Students are given the opportunity to examine and recognize problems” and the problems must attract their attention without being at such a high level that students could be discouraged (Akinoglu & Tandogan, 2007, p. 73). A well-designed “project” increases student interest and satisfaction (Richards, Adsit & Ford, 2012).

Finally the solution is presented to classmates or the community. This presentation may take many different forms.

Benefits of the problem-based learning method

According to Tarhan, Ayar-Kayali, Urek and Acar (2008), “the most important responsibility of education is to give individuals the ability to learn, reason, think creatively and critically, make decisions, solve problems and function as part of a team” (p. 296). PBL is one of the methods providing evidence that it can achieve all these goals of education.

Increase of standard scores

When implementing a new educational program in a school, one of the first actions is to determine if student achievement on standard tests will increase with the new program. Norman & Schmidt (2000), point out that “PBL does not result in dramatic differences in cognitive outcomes” (p. 721) but that “recall is better when the retrieval setting matches the setting of the original learning” (p. 722). Those interested in PBL often suggest that assessing student achievement by test scores tells only part of the story. They stress that a liberal education is as much about learning to work as teams, finding ways to solve problems, and developing good communication skills as it is about learning specific content.

Student Retention

Research indicates that short-term retention of content knowledge is similar in PBL and traditional settings (Hung et al., 2008). The degree of content knowledge acquisition varies with the research but most agree that there is no significant difference between traditional teaching and PBL (Carrio, Larramona, Banos & Perez, 2011; Hung et al., 2008; Schmidt et al., 2011). Barron et al., (1998) found that the acquisition improves if students define clear goals. Richards et al., (2012) added that students gained valuable scientific processing skills. Furthermore according to Savery (2006), there is “a gap in the research on the short-term and long-term effectiveness of using PBL” (p. 11).

The PBL method encourages longer-term retention of content knowledge than in traditional classroom setting (Hung et al., 2008; Schmidt et al., 2011; Sungur & Tekkaya, 2006). Students make their own relevant connections to the new content leading to a better understanding and better applications (Hung et al., 2008; Sungur & Tekkaya, 2006). Students seem to find the topics to be more interesting (Kendler & Grove, 2004) because they reflect real life situations (Sungur & Tekkaya, 2006). “While searching for solutions to problems, they (students) learn in the context in which the knowledge is to be used” (Chin & Chia, 2004, p. 69). The PBL method helps student increase their recall of knowledge (Schmidt et al., 2011). "The way the knowledge is anchored in specific context is more meaningful, more integrated, better retained and more transferable” (Hung et al., 2008, p. 488). Students who actively participate in the problem/solutions will remember their experiences better than students not engaged in the process (Barron et al., 1998). Students can see the bigger picture and this help them remember the material (Chin & Chia, 2004). Dunlap (2008) and Norman & Schmidt (2001) state that PBL prompts the students to access relevant prior knowledge and helps the students to assimilate new learning. Students have to decide if they possess the prior knowledge. They need to compare what they already know with what they find to decide if it is relevant to the problem. At this point they learn the content in context.

Cross-curricular connections

PBL is a method that can be used in cross-curricular settings (Belland et al., 2009; Savery, 2006). Students realize that material learned in other disciplines can be useful in PBL because problems are complex and of an interdisciplinary nature that solutions require knowledge from various courses (Dunlap, 2005). Students are also able to recall the knowledge acquired during the PBL and connect it to other disciplines (Sungur & Tekkaya, 2006).

At the same time the students are gaining content knowledge, they are employing problem-solving skills (Hung et al., 2008; Belland et al., 2009). Students define the problem and the steps that need to be taken to find a possible solution (Hung et al., 2008). Students set goals to reach, make hypothesis, propose ways to work out the problem and evaluate their resources (Dunlap, 2005). However, if not enough time is dedicated to self or group communication and assessment, students can miss content knowledge (Barron et al., 1998). Some other goals achieved in PBL are the development of professional reasoning and skills (Carrio et al., 2011) and citizen responsibilities, which are sometimes difficult to attain in traditional classroom settings (Dunlap, 2005).

Individual learning

An important consequence of PBL has been seen to be the degree to which students become self-directed learners (Belland et al., 2009; Dunlap, 2005; Hung et al., 2008; Hmelo-Silver & Barrows, 2006; Savery, 2006). The act of solving a problem and articulating conclusions often results in the formulation of creative responses (Chin & Chia, 2004; Tarhan et al., 2008). Another important aspect of PBL is the ease with which it can be adapted to accommodate for various learning styles and abilities "as there are alternative ways of reaching a solution" (Chin & Chia, 2004, p. 70). Additionally students become more aware of the limitation of their own knowledge (Hmelo-Silver & Barrows, 2006). Students learn how to learn (Akinoglu & Tandogan, 2007; Khairiree & Kurusatian, 2009), develop self-management skills (Carrio et al., 2011) and are able to better pace their learning (Dunlap, 2005). "Students who studied beyond the agreed learning issues spent more time on individual study and performed better on achievement tests" (Schmidt et al., 2011, p. 798). Gordon et al (as cited in Sungur & Tekkaya, 2006) tell us that the problem stimulates students to carry out investigations to satisfy their need to know, then links the new knowledge into their thinking and decision-making processes. Festus & Ekpete's research (2012) supports the idea that students exposed to the problem–based method had a more positive mindset than the students exposed to traditional teaching. As a result of being more engaged in their learning and presenting their solutions to classmates or the community (Belland et al., 2009; Carrio et al., 2011) the students' confidence in public speaking increases.

PBL encourages the students to be self-reflective (Hung et al., 2008; Dunlap, 2005). Students monitor their own learning when communicating with members of their groups.

They develop skills in reasoning and even start to question the validity of the information they collected (Hmelo-Silver & Barrows, 2006). Students have to reassess and redefine the problem as they progress in their learning. Barron et al., (1998) explain that frequent assessment opportunities help redirect the research for the solution. Teacher assessment is just as important in the process and ensures that the students are meeting the goals needed to succeed. The problem definition changes as new information is gathered (Chin & Chia, 2004). The process encourages regular studying (Schmidt et al., 2011) and lifelong learning (Dunlap, 2005). Tarhan et al., (2008) found that "75% of the students commented that in contrast to the traditional approach, they must study continually under PBL, because if they did not research and study, they could not solve the problem"(p. 298).

In addition to self-motivated learning, researchers identified higher level questioning and greater use of critical thinking (Sungur & Tekkaya, 2006; Tarhan et al., 2008). Students have to plan and carry out inquiry tasks (Belland et al., 2009). Students "set goals and create action plans for achieving those goals" (Dunalp, 2005, p. 14), and look for alternative solutions (Sungur & Tekkaya, 2006). Finally according to Tarhan et al., 2008, PBL is clearly superior in helping students to effectively construct knowledge in the subject matter, and to think critically and creatively (p. 297). Akinoglu & Tandogan, 2007, tell us that PBL "develops student's high level thinking/critical thinking and scientific thinking skills"(p. 73).

Collaboration.

PBL changes the role the students take in the learning process. Activities are student centered and the student is no longer an information receiver (Hung et al., 2008). PBL "supports the student's movement from a passive receiver of already established knowledge to an active, reflective learner" (Akinoglu & Tandogan, 2007, p. 72; Barron et al., 1998, p.

285). PBL requires collaboration and communication between different levels of students (Savery, 2006). PBL promotes cooperative learning where all students are able to complete tasks that more closely suit their abilities (Belland et al., 2009). Students can take many roles such as leader, recorder, timekeeper, reflector or being placed in the position of arguing the nature of the information collected (Tarhan et al. 2008). Furthermore Belland et al. (2009) identified that PBL increased communication between students in a group made of mainstream students and students with special needs. Each student brings something new to the group and takes separate well-defined role in the group (even if the students do not realize they take different roles in problem solving situations). Students have to communicate the results from their own research. Carrio et al. (2011) identified an increase of communication skills within the group and Khairiree & Kurusatian (2009) identified the same increase in communication as well as an increase between students and the teacher and the students with the community. Students in PBL take advantage of "human-oriented resources such as peers, teams, informal social network and communities of practice" (Dunlap, 2005, p. 6). Kendler & Grove (2004) outline that students recognized that all members of the team had the opportunity to speak in the group but also to present the information they gathered. Schmidt et al. (2011) also point out that increase communications foster the development of friendship within the group. Barron et al. (1998) acknowledged as well that social organization promotes participation. Finally even students recognize that they would not have been able to do the "project" on their own (Chin & Chia, 2004).

When involved in finding a solution in PBL, students are able to determine what they know and what they need to know (Belland et al., 2009; Savery, 2006). They collectively determine the solution to the problem (Belland et al., 2009; Kendler & Grove, 2004) and take ownership in their learning (Barron et al., 1998). When the problem reflects a real life situation the students have tendency to take a role in the search for the solution and learn on their own outside of the classroom (Chin & Chia, 2004) increasing their sense of fulfillment and accomplishment. According to Tarhan et al., (2008) "students with previous low achievement explained that working in the group increased their knowledge greatly, and that they became more confident" (p. 298). Students become independent learners (Sungur & Tekkaya, 2006) and reflect on the quality of their work to go beyond what they know or need to solve the problem (Dunlap, 2005). However Schmidt et al. (2011) say that it takes time for the students to go beyond what is needed. With practice the students start to question the information they found and progressively begin to take the facilitation role (Hmelo-Silver & Barrows, 2006). Motivation and social confidence increased when the students in the group have different level of abilities (Belland et al., 2009). Students became more enthusiastic toward the task that was asked of them (Barron et al., 1998; Norman & Schmidt, 2001). Because students are able to choose how to solve the problem, PBL is more enjoyable and increases student interest (Sungur & Tekkaya, 2006). Students even share their experience with other students or family members not involved in PBL (Norman & Schmidt, 2001). Overall students have positive experiences and increased satisfaction (Chin & Chia, 2004).

Issues with problem-based learning

Research also identified issues with problem-based learning. Most of the research on problem-based learning has been conducted in the medical field since it was first established in this area. Several concerns were addressed in the studies but these concerns can be applied to any level or subject. According to Azer (2001), personal preferences and habits can delay the implementation of a different teaching method. Personal interests, beliefs, academic backgrounds, openness to change are just few of the factors that can prevent an educator from trying problem-based learning. Only a limited amount of teachers venture in the use of PBL (Barron et al., 1998). Because of the many alternative solutions students will develop, there is no way the teachers will know the answers to all students' questions and as a result the teachers need to be aware of his/her own knowledge limitations (Hmelo-Silver & Barrows, 2006).

Unknown

Uncertainty associated with a new method can be stressful for the person deciding to make a shift (Azer, 2001). Stress is not only affecting the teacher but it is also affecting the students who are experiencing PBL for the first time. According to Savery (2006), "the learners who are new to PBL require significant instructional scaffolding to support the development of problem-solving skills, self-directed skills, and teamwork/collaboration skills to a level of self-sufficiency where the scaffolds can be removed"(p. 15). All individual contributions need to be made for the success of the group and for the group to continue seeking the solution to the problem (Barron et al., 1998). Small group learning with students of different personalities and learning styles, and undefined objectives can make students uneasy about the process (Hung et al., 2008). The students are expected to get knowledge from their PBL experience but unfortunately dysfunctional groups lacking all members' participation, and well-defined tasks with time for reflections on learning and behavior is ineffective (Richards et al., 2012). Some students found that some group members were "too bossy" (Chin & Chia, 2004, p. 74). Students can argue over what the next step in the process should be, and over what needs to be included in their presentation (Chin & Chia, 2004). It may also be difficult for teachers as groups may finish at different time (Akinoglu

& Tandogan, 2007). Students feel like they do not get adequate time to work on the solution (Kendler & Grove, 2004). Furthermore because of its difficulty of implementation in large group due to reduced instructor/student attention PBL was highly criticized (Richards et al., 2012).

Cognitive demand

Students have to think harder than they are used to (Chin & Chia, 2004). They have to read, synthesize and reword the information gathered for the problem but most have had little exposure to these types of activities (Sungur & Tekkaya, 2006). Students are unsure of having the correct response/solution since there are multiple outcomes to one problem (Chin & Chia, 2004; Kendler & Grove, 2004). At first the students are unable to assess their own learning. They do not believe they make progress and can be overwhelmed with the amount of work required by PBL (Dunlap, 2005). Problem-based learning requires more individual work outside the classroom (Chin & Chia, 2004). Unfortunately some students do not study much beyond the learning issues generated by the problem (Schmidt et al., 2011).

Beside human preferences and stress, Hung et al., (2008) point out that the curriculum design is significant in the success of the method. In his study, Azer (2001) identified several challenges across various course topics. Differences in culture and political systems can limit the use of PBL at an institutional level or even at a personal level. Transitioning to a PBL curriculum is resource intensive and time consuming (Tarhan et al., 2008). Faculty and student commitments, support personnel, instructional materials and facilities all need to be factored in the cost of adopting a new teaching method (Azer, 2001; Richards et al., 2012).

Having an “appropriate tutor” (p. 392) is key to a good problem-base learning experience (Azer, 2001). The tutor is a facilitator and does not disperse content knowledge. Without tutor support PBL may be difficult to integrate successfully in a curriculum (Richards et al., 2012).

PBL as an alternate teaching method

According to Savery (2006), “high-stakes standardized testing tends to support instructional approaches that teach to the test. These approaches focus primarily on memorization through drill and practice, and rehearsal using practice tests” (p. 18). Because many teachers have to follow a curriculum set in place by their district or state, there is not much time for teachers and students to work in depth on a problem (Savery, 2006). PBL covers a large variety of topics but it is uncertain if PBL cover adequate content areas required by curricula (Hung et al., 2008). There are conflicting data showing no significant difference in content acquisition (Norman & Schmidt, 2001). Another challenge for teachers is to move from the information provider role to a facilitator role (Savery, 2006). As more teachers transition to PBL from teacher-centered learning, curriculum should be revised, and more teachers should be trained (Tarhan et al., 2008). According to Savery (2006), PBL “must be the pedagogical base in the curriculum and not part of a didactic curriculum” (p. 14).

Although PBL seems to have its own set of problems, Azer (2001) recognizes that “using different teaching techniques may be more effective for improving different elements of skills learning”(p. 395) and that “[s]olving problems is a process of discovery that is much more open and linked to reasoning”(p. 391). "If PBL is used in high school settings more widely, this could assist students to develop those skills that they need to be successful in their life" (Tarhan et al., 2008, p. 298).

Differences between male and female students

Over time there have been several studies about the differences in attitude between male and female students toward science. The studies reflect the differences across several nations, ages and achievement levels. For the most parts the research shows similar results.

Performance and attitudes

Based on the results of the National Assessment of Education Progress (NAEP)'s first assessment (as cited in Kahle, 2004), male students outperformed female students in science in all age groups, with the difference increasing with age. Brotman and Moore (2008), Kahle and Rennie (1993) and Weinburgh's meta-analysis (1995) also describe the difference in attitude and performance in science. Weinburgh (1995) states that there is a "strong positive relationship between attitude toward science and achievement in science" and that the "relationship was stronger for girls than for boys" (p. 392). Another interesting fact reported by Weinburgh (1995) was that the high-performance girls had "a slightly more positive attitude toward science than boys" and that the low-performance and general performance "boys showed a more positive attitude than girls" (p. 393).

Science topics

Sikora and Pokropek (2012) point out that in the results of the 2006 Program for International Student Assessment, the "overall interest in science careers among boys and girls is at comparable levels" however the type of science occupations chosen by the students vary by gender (p. 242). In all 50 countries, industrialized and transforming nations, boys chose careers related to computing, engineering or mathematics while girls chose careers related to biology, agriculture or health (Sikora & Pokropeck, 2012). It is important to note that the achievement difference between genders was greater in the physical, chemical, earth and space sciences than in the biological sciences (Brotman & Moore, 2008; Kahle & Rennie, 2004,). Weinburgh and Engelhard (as cited in Weinburgh, 1995) and Schibeci (as cited in Weinburgh, 1995) report that girls had a more positive attitude toward biology. Johnson (as cited in Weinburgh, 1995) also reports that topics such as plant parts, growing seeds, how animals have young, medical applications were of higher interest to girls. Brotman and Moore (2008) point out that "girls are attracted in topics that involve helping others" (p. 979) and that according to the work of Gilligan (as cited in Brotman & Moore, 2008) women are more focused on relationships and connections. According to Sikora and Pokropek (2012) "women are better at care, nurturance and human interaction"(p. 255). Furthermore Brotman and Moore (2008) indicate that "girls were more likely to only be interested in physics topics that relate to their lives and society" (p. 983). Weinburgh (1995) agrees that "the relationship between attitude and achievement in biology is higher than in physics" for girls (p. 393).

Johnson (as cited in Weinburgh, 1995) states that topics in speed, electric circuit, floating and sinking and technical applications were of higher interest to boys. Schibeci (as cited in Weinburgh, 1995) also reports that boys showed a more positive attitude toward physics and chemistry while Sikora and Pokropek (2012) express that "men excel at abstract thinking, problem solving and analysis" (p. 255).

Perceptions and Practices

"Girls interest in and attitudes about and enjoyment of science are restricted by the type and kind of science they have experienced" (Kahle & Rennie, 1993, p. 332). Overall girls are more likely to be exposed to natural or biological science than physical or chemical sciences in and out of school. According to the results reported by the NAEP (as cited in Kahle, 2004), in the attitudinal questions girls wanted to do more science activities than they were doing both in and out of school. The girls also had restricted view of what they could do with science and could not picture themselves as a scientists. These results support the findings of Rennie and Dunne (1994) done with 16 years old students in Fiji in which "females are less stereotyped than males in their views, [but] only 10% of them are likely to choose a science-related occupation which is not associated with service to health, compared to about 30% in males"(p. 298). In the same research Rennie and Dunne (1994) show that "differences in science participation are determined by socioeconomic and cultural factors, not innate ones, just as they seem to be elsewhere" (p. 299). Moreover according to Handley and Morse (as cited in Weinburgh, 1995) girls associate science as being more related to male positions.

In another research, Kahle and Rennie (1993) found that the use of cooperative learning group, laboratories, discussions and hands on activities in science are more equitable teaching techniques. According to Brotman and Moore (2008), giving students choices, using topics in which women are expected to be expert or having real life connection "has the potential to engage girls in science" (p. 983). Bailey (1993) also points out that increasing the wait time before calling on students may increase the number of girls volunteering answers. According to Bailey (1993) the change from the more personal environment of elementary school to the more impersonal environment of junior high may be more difficult for girls than for boys. Another difference observed by Kahle and Rennie (1993) was that boys were more confident of their own abilities than girls were of themselves. Sikora and Pokropek (2012) also found that "almost everywhere girls have lower science self-concept than boys, even if their academic performance matches with that of their male peers"(p. 244). In a meta-analysis of articles ranging from 1914 to 2011, Voyer and Voyer (2014) reaffirm that female students school performance matched or outperformed male students while male students were better at taking tests. According to Kenney-Benson et al. (as cited in Voyer & Voyer , 2014) "the learning style of females tends to emphasize mastery over performance in task completion, whereas males tend to show the reverse emphasis" (p. 1192). Finally Brotman and Moore (2008) found that girls were less competitive than boys.

While gender difference was greatly studied in the 1980's and early 1990's, it is still undeniably observed in the classroom today at different levels; unfortunately not as many research have been done in the last decade. Approximately twenty-three percent of articles used in Voyer and Voyer's (2014) meta-analysis sample size of 369 were from 2005 until 2011; however their research focused in girls' performance in the classroom.

Chapter 3

Methodology

The purpose of the study is to compare achievement and attitudes of biology students when taught using problem-based learning (PBL) and traditional teaching methods. The specific questions are: (1) What is the difference in content knowledge as exhibited on a multiple-choice test (similar to state test) when academic biology students are exposed to two different teaching methods (traditional and PBL)? (2) How do male and female students compare with regard to content knowledge? (3) How do students' perceptions of learned skills between the two different teaching methods differ?

Research Design

Participants

The study took place in a suburban high school of a large metropolitan area. The 79 participants for this study were recruited from the 278 students enrolled in academic biology classes during the 2013-2014 school year. All students were invited to participate and no students were excluded. The majority of the students were 9th grade students with few 10th and 11th graders.

An information letter about the study was sent to the parents at the same time the assent and permission forms were sent home. The same information was sent via email to the parents and was posted on the teachers' websites. The forms and information about the study were given in both English and Spanish to accommodate the large Spanish-speaking population enrolled in biology (representing 10% of the students). The ESL teacher, a principal's secretary and a Spanish teacher on campus helped with the translation of the documents. In order to use the data collected from the students, the students and parents completed their respective consent forms.

The four biology teachers at the school planned for the lesson to ensure that they covered the same content materials. The two teachers that participated in the study were female teachers but had different background, years of experience and time in the school. One of the teacher was a 19 years veteran teacher who taught 6th through 12th graders. She taught general science, life science, earth science, physical science, biology and environmental science, in a private school on an island in a US Territory and in suburban public schools of a large metropolitan area. The second teacher had less than 10 years experience. She previously taught biology in urban high schools in a different state and it was her first year in the district.

Design & Instruments

Two ten-day units, which resulted in comparable test scores in previous years, were used. The first unit on biomolecules was presented in a traditional setting while the second unit on cells was presented in a PBL format. The cell unit using the PBL method was the first time the students were exposed to PBL. Appendix A compares the activities for both units. Appendix B includes the students' introduction to the problem and the different roles the students take in the activity. The teachers followed the students closely and supported them in their research.

Data were collected using two instruments:

- Multiple-choice tests for assessing content knowledge acquisition (Appendix C –The questions were chosen by the biology team of four teachers and drawn from various states released end of course exams).
- A survey for assessing students' perceptions. (Appendix D- The questions were chosen by the biology team of four teachers).

Content Acquisition

To determine if there was a difference in content knowledge as exhibited on a multiple-choice test; a pre-test/post-test format was used. Before the first unit the students took a pre-assessment of their overall knowledge on biology topics as part of the regular events of the course. The pre-assessment was a multiple-choice test where the questions measured student knowledge of the biology Texas Essential Knowledge and Skills (TEKS) studied the first semester**.** The questions were chosen from released End of Course (EOC) biology exams from various states.

At the end of each unit, the students took a similar test as a post-assessment containing some of the same questions as the pre-assessment on the TEKS (Texas Essential Knowledge and Skills) studied in the unit. Then questions common to both pre- and post-assessment were examined to see if there was a difference in content knowledge acquisition after the two teaching methods. Secondly, the same data were analyzed to determine if there was a difference between male and female students' scores.

The subgroups are identified in table 1.

Table 1.
Student groups and numbers.

	Male	Female	Total
Population	145	133	278
Qualifying students with permission	34	45	79

Students' perceptions

To determine if there was a difference in students' perception of learned skills between the two different teaching methods, at the end of both units the students completed a 10-question Likert scale survey developed by the researcher (Appendix D). Some of the questions surveyed students on how they felt about working in groups, some questions asked about the skills they learned while working on the units and some were about their preferences.

Data Analysis

Question 1 and 2: Content Knowledge Analysis

The researcher only analyzed the data from the students who returned both consent forms in addition to have completed both pre/post tests and surveys. In order to provide anonymity, a 3-digit number replaced students' names. Additionally the results from only the questions common to both pre-test and post-test were analyzed.

The data were analyzed using the SPSS (statistical package for the social science) program. A three-way ANOVA was used to investigate the main effects of time, method, gender and interactions between main effects.

Question 3: Likert Scale Survey

A number value was assigned to each possible answer in the survey. The number value increased from a 1 (strongly disagree), 2 (disagree), 3 (neither agree or disagree), 4 (agree), to 5 (strongly disagree). Survey ratings were subjected to a principle component factor analysis to establish correlations between questions. Several factors were recorded but the loadings were inconsistent between PBL and the traditional method. Only one interpretable factor emerged for both methods; therefore a combined score for the three questions identified was used. Additionally, three other questions were selected by the researcher based on what research previously found and what would answer the research questions. The ratings from the four questions were subjected to individual two-way ANOVAs, with instructional method and gender as the independent variables.

Chapter 4

Results

Test scores and student surveys provided the data for this study. The specific questions are: (1) What is the difference in content knowledge as exhibited on a multiple-choice test (similar to state test) when academic biology students are exposed to two different teaching methods (traditional and PBL)? (2) How do male and female students compare with regard to content knowledge? (3) How do students' perceptions of learned skills between the two teaching methods differ?

Test scores

The first step in analysis was to calculate the means and standard deviations using percentages for the two instructional methods prior to and after instruction (Table 2). In addition, the scores were further broken down by gender. Both the biochemistry unit (taught with the traditional method) and the cell unit (taught with the PBL method) resulted in a significant gain for males, females and all from pre to post instruction.

Table 2
Means and standard deviations for test scores [a].

Method	Time	Student	Mean	Std. Deviation
Traditional	Pre-test	Male	33.82	15.77
		Female	40.22	16.44
		Total	37.47	16.37
	Post-test	Male	66.47	17.73
		Female	58.22	23.57
		Total	61.77	21.53
PBL	Pre-test	Male	42.02	19.42
		Female	44.13	21.50
		Total	43.22	20.45
	Post-Test	Male	79.41	18.34
		Female	73.97	18.35
		Total	76.31	18.42

Note. The traditional method was used with the Biochemistry unit.
The PBL method was used with the Cell unit.
[a] *Scores are % correct on each unit test.*

Main effects

To test the difference in performance, students' scores on the biochemistry unit (taught with the traditional method) and on the cell unit (taught with the PBL method) were analyzed using an analysis of variance. A three-way ANOVA was used to study the main effects of time, method, gender and the interaction of time with gender, time with method, method with gender and the interaction of all three main effects. Two of the three main effects were significant. The difference in performance from pre-test to post-test was significant $F(1, 77)=189.17$; $p< .001$ with post-scores significantly higher than pre-test score. Also, the difference in performance from traditional to PBL was significant $F(1, 77) =30.01$; $p< .001$ with PBL scores significantly higher than traditional scores overall. The only variable that did not show a significant difference was in performance between male and female students.

Interactions results

There was no significant interaction for neither method by gender or the three-way interaction. There was significant interaction for time by gender $F(1,77)=6.71$; $p < .02$ (Figure 1). Male students' scores increased more dramatically from pre- to post-test than did females.

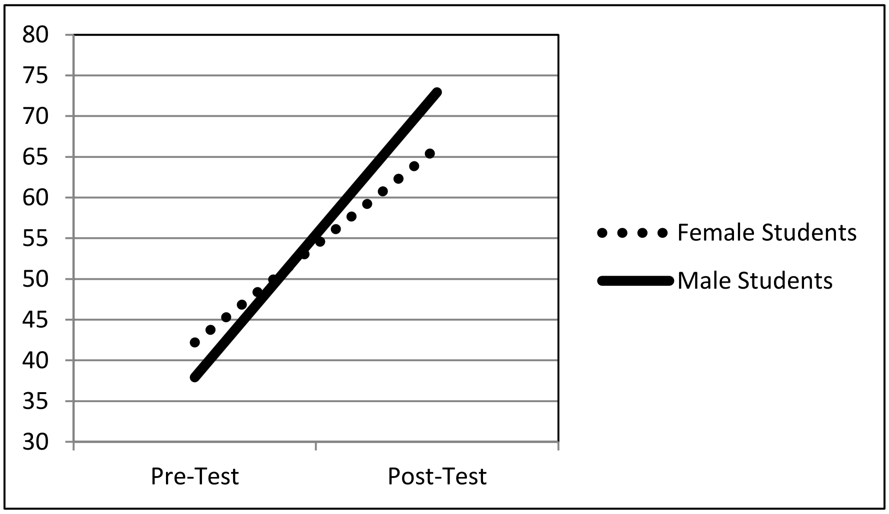


Figure 1. Male and female students' mean scores for both methods from pre to post test.

There was significant interaction for time by method $F(1,77)=5.72$; $p < .02$ (Figure 2).

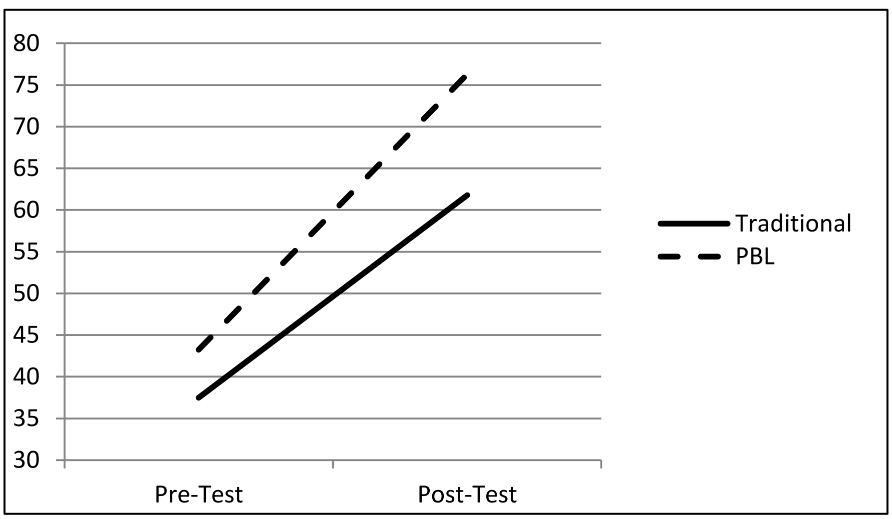


Figure 2. Students' mean scores from pre-test to post-test for both methods.

PBL scores showed a greater increase from pre- to post-test than did scores for traditional instruction.

There was no significant interaction for either method by gender or the three-way interaction (Figures 3 and 4).

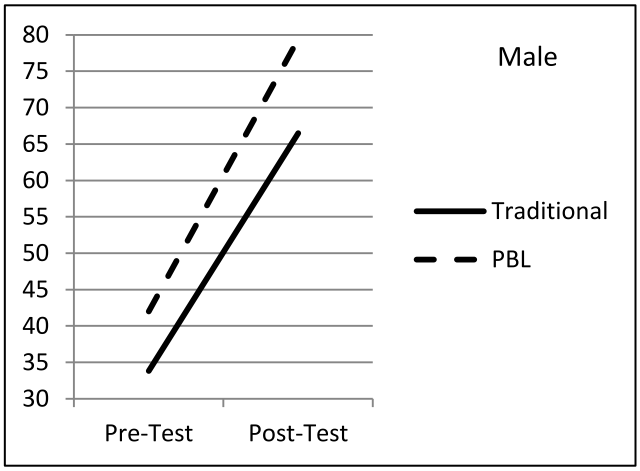


Figure 3. Male students' mean scores from pre-test to post-test for both methods.

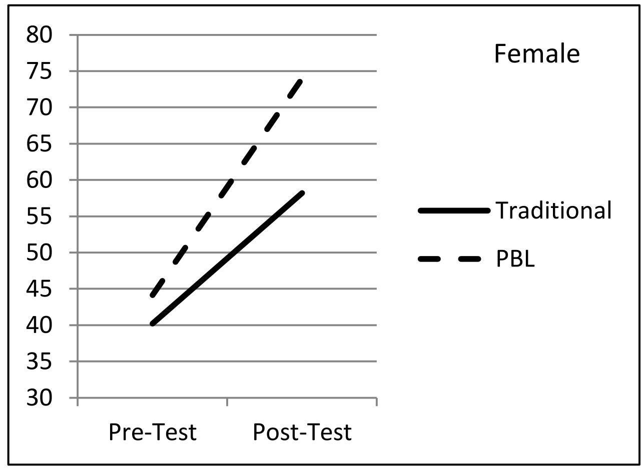


Figure 4. Female students' mean score from pre-test to post-test for both methods.

Data collected from survey items

Appendix D presents the survey questions the students answered. In an attempt to reduce the number of items for analysis, the ratings were subjected to a principle component factor analysis. Several factors emerged but the loadings were inconsistent. Only one interpretable factor emerged for both methods. The three questions that loaded together were the items 2,6,9 relating to learning to work together, communication and conflict resolution, and learning from the interaction. All indicated a perception of communication and interaction while working together. Therefore a mean rating was used for those three questions.

Table 3 displays the results from the factor analysis.

Table 3
Factor loadings for survey items

Questions	Traditional Method	PBL Method
1-Like the Method	.431	.309
2-Learn to work with others	.889	.773
3-Connect with real life	.440	.315
4-Use technology	.022	.669
5-Confident and can explain	.308	.335
6-Communication and conflict resolution	.723	.859
7-Learn with notes	.136	.618
8-Prepared to solve a problem	.131	.388
9-Learn from interaction	.733	.701
10-Frustrated	.082	.189

Note. The traditional method was used with the Biochemistry unit.
The PBL method was used with the Cell unit.

Some questions (1,4,7,10) were not pertinent to the research but were used to report to other teachers. Three other items were analyzed for the purpose of the study. The questions 3,5,8 that related to the connection to real life experience, confidence in learning and explaining what was learned, and feeling prepared to solve a problem were more closely examined.

Table 4 shows the mean ratings for the selected items.

Table 4

Means and standard deviation for mean ratings for the selected survey items [a].

Questions & Method	Student	Mean	Std. deviation
Communication/Interaction			
Traditional	Male	3.61	.72
	Female	3.36	.92
PBL	Male	3.50	.80
	Female	3.44	1.11
5-Confident and can explain			
Traditional	Male	3.38	.82
	Female	2.91	1.02
PBL	Male	3.38	.74
	Female	2.96	1.06
8-Prepared to solve a problem			
Traditional	Male	3.59	.86
	Female	3.07	.99
PBL	Male	3.68	1.01
	Female	2.91	.95
3-Connect with real life			
Traditional	Male	3.44	.96
	Female	3.36	.98
PBL	Male	3.38	1.16
	Female	3.42	.97

Note. The traditional method was used with the Biochemistry unit.
The PBL method was used with the Cell unit.
[a] *The mean rating represents the possible answers the students chose with 1-strongly disagree, 2-disagree, 3-neither, 4-agree and 5-strongly agree.*

The combined scores of the communication and interaction loading, and the scores from questions 3,5,8 were subjected to four two-way ANOVAs with type of method as one factor and gender as the other. There was no significant difference between the students' perception of communication/interaction between the two methods.

Question 3: There was no significant difference between male and female students perception of being able to connect to real life experience in the two methods.

Question 5: Male students reported having more confidence than female students $F(1,77)=6.42$; $p < .02$. However there was no significant difference between the students' perceptions between the two methods.

Question 8: Male students had a significantly higher rating in their perception of being able to solve a problem than female students $F(1,77)=14.23$; $p < .001$. However students' perceptions of the two methods did not differ significantly.

Chapter 5

Discussion

The results of this study provide important information for teachers who are responsible for deciding on the instructional methods to be used throughout an academic year. Although students gained conceptual knowledge of the science topic using both instructional methods, some notable differences were identified. For clarity, the discussion is organized by research question type.

Questions 1 and 2: (1) What is the difference in content knowledge as exhibited on a multiple-choice test (similar to state test) when academic biology students are exposed to two different teaching methods (traditional and PBL)? (2) How do male and female students compare with regard to content knowledge?

Based on the data collected from the test scores, there was a significant difference between the pre and post-test for both methods. As expected, students' mean scores increased after being exposed to the new content material. This increase was expected because the teachers planned and used the best instruction within the two methodologies. The biochemistry (traditional unit) mean pre-test score was 37.47 and increased to 61.77 post-test or the equivalent of 24.3 points difference in percent correct. The cell (PBL unit) mean pre-test score was 43.22 and increased to 76.31 post-test or the equivalent of 33.09 points difference in percent correct. The students' scores increased regardless of the method used for instruction. While both methods increased students scores, the PBL unit increased the most and more students were successful on the test.

Furthermore, there was a significant difference pre to post between the two methods. The scores on the pre-test indicated that the students began the unit on the cell with more content knowledge than on biochemistry. However the units were chosen because they yielded similar results in the previous year. The difference in the initial mean score may be explained by a general familiarity with cells and cell structure as opposed to biochemistry. The difference in the post-instruction is probably due to the methods the students were exposed to, the way the material was presented to the students or possibly the difference in topics.

The interaction data shows that male students' mean scores increased more than the female students regardless of the method. The male students' mean scores jumped from 37.92 pre-test to 72.94 post-test (35.02 points difference). Meanwhile the female students mean scores went from 42.18 pre-test to 66.10 post-test (23.92 points difference). It is interesting to note that the females began with a slightly higher pre-instruction score but did not demonstrate the same rate of growth as the males. Scores in both groups increased due to exposure to the new content material. One explanation for the difference may be that the male students may have been exposed to more science than girls outside of the school (Brotman & Moore, 2008). Another possible reason for the difference was the topic of each unit.

There was a significant difference in mean scores between the pre and post-test with the two methods used to teach the separate units. The biochemistry (traditional unit) mean pre-test score was 37.47 and increased to 61.77 post-test. The cell (PBL unit) mean pre-test score was 43.22 and increased to 76.31 post-test. There was 23.5% difference in post-test scores between the two methods with PBL having the greatest numbers. The difference between the scores was probably due to the fact that the biochemistry unit was taught using notes where the students were passive receivers of knowledge and completed labs to explore biomolecules, whereas the cell unit made the students more actively involved in solving the problem, researching the causes and solutions to the problem. Again the topic of the unit using PBL may have been of better interest to the students.

The difference between genders in interaction with different methods was not significant. However the patterns of increase between male and female students had different patterns (Figure 3 and 4). The male students' scores in the PBL was almost parallel to their increased scores in the traditional method. Their cell unit pre-test was higher than the female students and increased in the same pattern as the traditional method, and finished with a higher score for the unit using the PBL method. Just like for the male students, the female students scores increased for both methods but the increase was more pronounced for the PBL method. The slope difference between the two methods can possibly be explained by previous research. Female students have tendency to learn better where there is social interaction (Botman & Moore, 2008; Sikora & Pokropek, 2015). The topic used in PBL may have been of better interest to girls than boys since the unit dealt with human diseases.
The overall results of this data show that the PBL was just as effective as the traditional method to get the students to learn the content material. Both male and female students' scores improved without really making a difference between genders and the post-test scores were higher with the PBL methods.

Question: (3) How do students' perceptions of learned skills between the two teaching methods differ?

To answer the perception questions, the students completed a survey at the end of both units. Out of the 10 questions the students answered, four big ideas were used for the purpose of the research:

- communication and interaction,
- learning by connection to real life experience,
- confidence in explaining the material learned,
- being prepared to solve a problem.

Based on the analysis of the questions there was no difference in students' perception of communication and interaction between the two methods. Even though the cell unit was designed to encourage students to communicate to solve the problem at hand, they also had to communicate during the labs used in the biomolecule unit.

Again there was no difference in perception in learning by using real life connections since both units involved solving a real life problem and completing a lab incorporating the use of food items to identify the biomolecule present in those foods. This may be explained by the fact that students are more willing to complete assignments if they can see the relevance in it (Hoostein, 1994; Kittrell & Moore, 2013). In both units the students could relate what they learned to their own health. They may have been more interested in the activity than if they would have just completed random questions on the topic.

Male students reported feeling more confident than the female students in being able to explain what they learned but the difference did not show between the two methods. The difference in confidence can be attributed to the fact that male students may have been more outspoken about the way they felt or may have been exposed to more real life science in their life. Another possibility could be that girls are more modest in their expression of confidence than boys (Kahle & Rennie, 1993).

In the same way male students felt they were more prepared at solving a problem than the female students but the difference did not show between the two methods used. In the biochemistry unit, using the traditional methods, the students practiced inquiry to identify the types of biomolecules found in food while in the cell unit, using the PBL method, the students had to identify a mystery disease. While both units did not intend to directly solve the same type of problem, they both had the students using their problem solving skills.

In general the survey showed that the students felt that they had used their communication and interaction skills, and they were able to connect to real life situation with both methods. Additionally male students felt more confident in being able to explain what they learned and being able to solve a problem than their counterparts. While there was a difference between male and female students in the last two survey items there was no difference in perception between the two methods. Overall the survey shows that there was no difference in perception between the two methods. Both traditional and PBL units in this study allowed the students to use their communication skills, solve problems, connect to real life and equally felt confident in explaining what they learned.

Recommendations

Finally, using the information collected from the research it is the recommendation of the researcher to add or to continue to use of the PBL method in the biology curriculum. The overall scores of the PBL increased between the pre and post-test in both genders and the increase was more significant with the PBL than the traditional method. Even though the students' perceptions of learned skills were similar with both methods, their overall scores with the PBL were higher than with the traditional method.

Limitations

Content knowledge questions

The research examined two separate biology units. The choice of the units was based on previously observed scores. It is impossible to say that the group of students participating in the study would have had the same results as the previous year using the same methods. It is also impossible to say if the results would have been similar if we had chosen the traditional method for the cell unit and the PBL method for the biochemistry unit. At that point, early in the school year, the students were only previously exposed once to research using technology. Only two out of the four biology teachers participated in the study. Two teachers were hesitant in trying something they were not familiar with. The two teachers who used the PBL method followed the same methods and activities in the units however it is certain that the delivery of the material was slightly different due to their different personalities.

While the intentions were to use a traditional approach in the biochemistry unit with lectures and worksheets, the students were not exclusively exposed to lectures and did other activities including labs. The activities were not PBL but allowed the students to be actively involved in the learning, and because of this the students did not perceive much difference between the two methods. It was also probably the first time for many students to participate in a PBL activity even though they were probably exposed to inquiry activities in the past. Students had many questions, needed much support and reassurance. Lastly because of the constraints in the district curriculum, the units were limited in the amount of time the study could use. The pre-test and post-test were only 10 days apart.

Perceptions

The students' survey had only 10 questions and was administered at the end of both units. Would the students' answers be different if the students had taken the survey at the end of each unit? Would a longer survey change the way the students thought about the units? Additional questions leading to the same idea but asked differently may have led to a better understanding of the students' perceptions of the two units.

Assessment

Most of the schools and standardized tests use multiple-choice assessment to measure students learning, as used in the research. This method of assessment does not measure higher level thinking skills acquired during the PBL method and is restricted to the measurement of content knowledge.

Further Study Ideas

Content knowledge questions

After doing this study, it would be interesting to find out if the results would differ if there had been more students involved in the study. The district where the study took place has 6 high schools with students from different cultural and economic backgrounds. Having a larger sample would have allowed for a better analysis of the different student subpopulations.

The study concentrated on only two units. How would the result differ if the study had used data from multiple units or units used after the students were familiar with the PBL method later in the year? The pre and post-tests were given ten days apart. To gage the learning experience and retention, a short-term post-test and a long-term post-test could be administered to students.

Perceptions

As far as the students' perceptions of the method are concerned, more questions could be used on the survey to identify more perception categories. If time was not an issue, the survey could be taken at the end of each unit. It is difficult to say if the students' perceptions of the two methods would be different after the PBL method was used once or multiple times throughout the year.

Parents, teachers and administrators could also be surveyed to find their opinions on the use of the method. Another survey could identify the teachers' opinion of the PBL method including costs and benefits. Another research could analyze the teacher's opinion about PBL after using it in their own classroom, by either giving them a complete unit or asking them to create one on their own.

Conclusion

The problem-based learning method while not widely used in public schools is a method teachers should consider in their classroom. The analysis of students' scores in this study shows that there was a significant increase in content knowledge over time regardless of the method used and the difference was more significant when using the problem-based learning method. Both male and female students were able to assimilate the content of the PBL unit and transfer their knowledge into a multiple-choice test similar to state test. Additionally male students reported having more confidence in what they learned and had higher rating in their perception of being able to solve a problem than female students. These results continue to corroborate other research on gender differences, meaning that there may still be a need to change female students' perceptions.

APPENDIX A

Schedule of Activities

Traditional Method: Biochemistry		Problem-based Method: Cells
Introduction to matter, molecule and water. Students take note in a foldable.	Day One	Introduction to "Mystery Disease" and introduction of patients' problems. Students will work in groups and each group is assigned one of three possible pathogens (Students are unaware of the differences to avoid exchange of information).
Biomolecule Chart-Part One Students research information and create a poster on one macromolecule.	Day Two	Students as Emergency Room Staff, create a report of the information they collected from the patients.
Biomolecule Chart-Part Two Students present or walk around the lab tables to collect data from the other groups about other macromolecules.	Day Three	Students as Emergency Room Staff, research the possible pathogen causing their disease.
Macromolecule models: Students identify the different elements, cut, color and create a model of each macromolecule.	Day Four	Students as Health Inspector investigate three pathogens giving similar symptoms and create an informational tri-fold brochure comparing and contrasting the pathogens.
Macromolecule models.	Day Five	Students finish the tri-fold brochure (some groups took three days).
Lab: Identify molecules in food.	Day Six	After creating the brochure the students as Health Inspector, determine which pathogen was the cause of their mystery disease and create a cartoon educational poster.
Lab: Identify molecules in food. Answer questions about digestion.	Day Seven	The poster explains the life cycle of the pathogen, how people get the disease and how to prevent getting the disease.
Murder and a meal activity. Intro to enzymes.	Day Eight	Presentation and recommendations. Students will present their findings and recommendations to the County Health Commissioners (2 or more teachers).
Enzyme activity.	Day Nine	Presentation and recommendations.
Test	Day Ten	Test

APPENDIX B

Problem-based cell unit: "Mystery Disease" Introduction

The temperatures are finally dropping, the rain is coming back and the water levels in our region lakes are again rising to normal. The tree leaves are changing colors and the State Fair just ended. Many people in our community enjoyed visiting the State Fair. It is the high point of the fall season. Carnival rides, carnival games, fried food, the buzzing sound of the crowd and the smell of the farm all indicate the school year is the midst of the first semester. Most students had a long weekend while "ag" students showed the animals they raised and competed with students from other schools. Most students came back refreshed from the long weekend and ready to start the new sixth week.

Unfortunately our school attendance secretaries started getting calls from parents reporting their children becoming sick-having flu like symptoms or some type of stomach bug. Over the last three weeks about 10% of the school population missed one or more days of school. The school nurse was contacted because of the great number of student absent. Therefore the nurse reported the numbers to our nearby hospital. The emergency room staff at the hospital informed the school nurse that they had also seen an increased number of patients over the last couple of weeks including children, adults and elderly persons all with similar symptoms.

Students Activities

Part One:

Students as emergency room staff create a report of the patients they are seeing. Students research the possible pathogen causing the illness.

Part Two:

Students as health inspectors, investigate, compare and contrast 3 pathogens producing similar symptoms and create a tri-fold brochure.

Part Three:

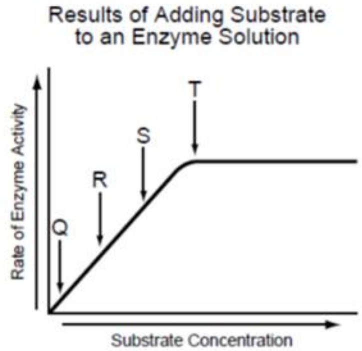
Students as health inspectors determine which pathogen caused their illness and create a cartoon-educational poster.

Part Four:

Students present their findings and recommendations to the county commissioners (2 or more teachers).

APPENDIX C

Pre-Assessment



***1.The graph shows the results of adding substrate to a solution that contains 10 grams of enzyme. At which point are all of the enzyme molecules working at their maximum rate?**

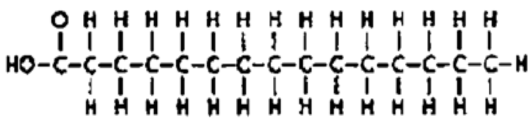
A. Q C. S

B. R D. T

***2. Which of the following biomolecules are most closely related to proteins?**

A. amino acids C. nucleotides

B. fatty acids D. Sugars



***3. Refer to the illustration above. Molecules like the one above are found in:**

A. carbohydrates. C. nucleic acids.

B. lipids. D. Proteins.

4. A structure within a cell that performs a specific function is called a(n):

A-organelle C-tissue

B-organ tissue D-biocenter

***5. What happens to an enzyme after the reaction it catalyzes has taken place?**

A. The enzyme is destroyed, and the cell must make another.

B. The enzyme holds on to the product until another enzyme removes it.

C. The enzyme is unchanged and ready to accept substrate molecules.

D. The enzyme changes shape so it can accept a different kind of substrate

***6. Which molecules store and transmit genetic information?**

A. lipids C. proteins

B. nucleic acids D. carbohydrates

7-The smallest units of life in all living things are:

A-cells C-mitochondria

B-cytoplasm D-golgi apparatuS

8-Only eukaryotic cells have:

A-DNA
B-membrane-bound organelles
C-ribosomes
D-cytoplasm

<u>Matching – Label the following as either a monomer (A) or polymer (B)</u>

*11 .Amino Acid
*12. Fatty Acid
*13 .Lipid

14-Which best explains why bacteria are classified as living and viruses are classified as nonliving?

a-bacteria are heterotrophic
b-bacteria are able to reproduce on their own while viruses cannot.
c-bacteria contain cellular organelles while viruses contain nucleic acid
d-bacteria require sunlight to survive, while viruses can live with or without sunlight.

15-Which best distinguishes between a plant cell and an animal cell?

a-plant cells have cell membranes, while animal cells have cell walls
b-plant cells contain centrioles, while animal cells contain chloroplasts
c-plant cells contain chloroplasts, while animal cells contain centrioles
d-plant cells have small vacuoles, while animal cells have large vacuoles

16- Which list shows the correct order of organization from simple to complex?

A-cell, community ,organism
B-cell, population, community
C-organism, community, population
D-community, population, organism

17-The H1N1 virus, commonly known as the swine flu, was declared a pandemic by the World Health Organization in 2009.
Which approach is most effective in preventing the spread of the virus?

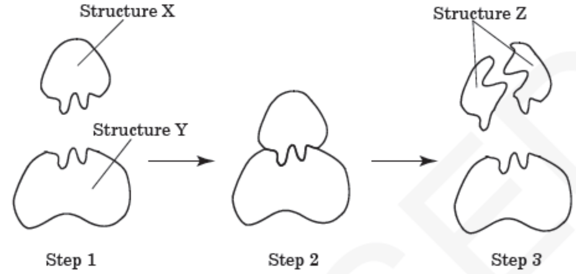
A-vaccination
B-use of antibiotics
C-use of fungicides
D-sterilization

***18-A sugar, a phosphate group and a nitrogen base form the building blocks of which organic compound?**

A-carbohydrates
B-nucleic acids
C-lipids
D-proteins

***20-This diagram shows an enzyme-substrate complex.**
Which is represented by structure X?

A-substrate
B-enzyme
C-product
D-complex



*Note: *Questions are from the biochemistry unit.*
Unmarked questions are from the cell unit.

APPENDIX D

Student Survey Questions

Unit Questionnaire **Student Name:___________________**

Answer the following questions by circling the choice that best describes what you feel:

1- I liked the way the unit on __________ was taught to me
1-Strongly disagree 2-Disagree 3-Neither agree nor disagree 4-Agree 5-Strongly agree

2- I learned to work with others
1-Strongly disagree 2-Disagree 3-Neither agree nor disagree 4-Agree 5-Strongly agree

3- I learned new concepts by being able to connect them to real life experience
1-Strongly disagree 2-Disagree 3-Neither agree nor disagree 4-Agree 5-Strongly agree

4- I used my Ipad and technology skills
1-Strongly disagree 2-Disagree 3-Neither agree nor disagree 4-Agree 5-Strongly agree

5- I feel confident in what I learned and can explain it.
1-Strongly disagree 2-Disagree 3-Neither agree nor disagree 4-Agree 5-Strongly agree

6- I learned to communicate and resolve conflict with others in my group
1-Strongly disagree 2-Disagree 3-Neither agree nor disagree 4-Agree 5-Strongly agree

7- I learned when the teacher gives new information (with notes)
1-Strongly disagree 2-Disagree 3-Neither agree nor disagree 4-Agree 5-Strongly agree

8- I feel more prepared to solve a problem
1-Strongly disagree 2-Disagree 3-Neither agree nor disagree 4-Agree 5-Strongly agree

9- I learned from interacting with other students
1-Strongly disagree 2-Disagree 3-Neither agree nor disagree 4-Agree 5-Strongly agree

10- I feel frustrated with the activities used in the unit
1-Strongly disagree 2-Disagree 3-Neither agree nor disagree 4-Agree 5-Strongly agree

Vita

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PROBLEM-BASED LEARNING EFFECTS IN 9TH GRADE BIOLOGY

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The purpose of the study is to compare the effects of problem-based learning with traditional teaching methods on 9th grade biology students. The research investigates the difference in content knowledge as exhibited on multiple-choice test when students are exposed to the two methods in two biology units. It looks at how male and female students compare with regard to content knowledge and how students' perceptions of learned skills differ between the two methods. At the end of the two units, the students learned the material with both methods but their scores were significantly higher after the problem-based learning method. Additionally, male students reported being more confident in what they learned and had higher rating in their perception of being able to solve a problem.

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