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PROBLEM-BASED LEARNING AND ITS APPLICATION INTO SCIENCE EDUCATION

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ABSTRACT : Science can provide humanity with knowledge about the biophysical environment and the social behaviors needed to develop effective solutions to humanity's local and global problems. Every day, people face with many problems, such as pollution, health problems, and family crises. It is essential that schools and teachers provide students with meaningful opportunities to help them solve problems. As a science educator, our most important goals are to teach children to be able to overcome real life problems. Therefore, we'd like to research how to assist students in developing skills to enable them to solve these problems. This research will focus on problem-based learning and its integration into science education. Specifically, this paper will answer the following questions: What is problem-based learning? How was problem-based learning organized? What are the advantages and disadvantages related to the use of problem-based learning? How can it be integrated into science instruction?

KEY WORDS: *Problem-based learning, problem- based learning curriculum, instructional methods, science education*

ÖZET: Bireyler yaşamları boyunca çevre kirliliği, sağlık ve ailevi sorunlar gibi birçok problemle karşılaşırlar. Bilim, insanı bölgesel ve evrensel problemlere etkili çözümler bulmasını sağlayacak bilgilerle donatır. Bu nedenle okullar da öğrencilere günlük hayatta karşılaşacakları problemleri çözmeyi öğreneceği fırsatlar yaratılmalıdır. Fen bilimi eğitimcileri olarak, öğrencilere gerçek hayatta karşılaşacakları problemleri çözmeyi öğretmek en önemli hedeflerden biri olmalıdır. Bu amaç doğrultusunda hazırlanan derleme türündeki bu çalışmada, öğrencilerin gerçek hayatta karşılaşacakları problemleri çözebilecek yetenekler kazanmasını sağlayacak "probleme-dayalı öğrenme" yöntemi açıklanarak araştırılmıştır. Fen bilgisi öğretimine nasıl entegre edilebileceği sorularına cevap vermeye çalışılmıştır.

ANAHTAR SÖZCÜKLER: *Probleme-dayalı öğrenme, probleme dayalı öğrenme müfredatı, öğretim metotları, fen bilgisi eğitimi*

1. INTRODUCTION

In traditional classrooms students experience problems after they have been presented with information. Students often do not know the rationale for the things they are learning. Often, the problems that students face, come from practice exercises that are so narrow in focus and abstract in context. Brooks and Brooks [1] state that "... the problems are presented to students after all information is taught, sending the implicit, though false, impression that professional problems only arise in venues where all the information needed for building is already at hand".

Most traditional instructional experiences for children are teacher-centered and textbook oriented, environments which are generally repetitious and poorly organized [2]. In 1956, Dewey [3] characterized these traditional educational experiences as a process of teaching knowledge into a child's mind instead of helping them develop their talents and abilities. In contrast, children should enjoy an exciting atmosphere in which they are provided with opportunities to explore their world [4]. Dewey [3] believed in constructing each child's environment based upon the interest of the child. He further stated that the school must connect classroom life to the child's life, in other words, the classroom needs to be as real as that is experienced in the child's home, neighborhood, and playground. This theory is known as the constructivist theory of education [5] which is the basis of problem-based learning [6].

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2. Problem Based Learning Curriculum

2.1. Problem-Based Learning

Problem-based learning (PBL) is a pedagogical strategy for posing significant, contextualized, real world situations and providing resources, guidance, and interaction to learners as they develop content knowledge and problem solving skills [7]. It is truly students-centered, helping students to be able to be responsible for their own learning style. In problem-based learning, students collaborate to study the issues of a problem as they strive to create viable solutions. Therefore, problem-based learning is different from the traditional learning methods (Table 1). Features of a problem-based learning are as follows: First one is the cumulative learning. That is, students are not taught in depth at any one time, but they are introduced repeatedly and in increasing levels of complexity during the course of study. Second one is the integrated learning. Here, students are introduced with interdisciplinary content as they relate to a problem. Third one is the progression in learning: what and how students learn changes as they get skills and knowledge throughout the time. Fourth one is consistency in learning. Thus, the aims of problem-based learning are reflected in all aspects of teaching and learning process, including the learning environment in the classroom while practicing. The same resources are available to students in PBL as to students in a more traditional curriculum. The primary difference is that, PBL students have responsibility to define which resources they will use. Resources available to PBL students include faculty, libraries, computer information system, computer laboratories and other laboratories.

PBL changes the order of the learning procedures (Table 2). It reflects the learning and problem-solving that occurs in real life. In the problem-based learning model, learning begins after students confront with an ill-structured problem - there is not meant to be one solution, and as new information is gathered in a reiterative process, perception of the problem, and thus the solution changes. All of the information that they collect for study are learned for solving the problem. Just as a scientist, who would not perform an experiment before identifying a question, students in problem-based learning class do not start learning until they have encountered an ill-structured problem to solve [8].

2.2. Origination of Problem-Based Learning

Problem-based learning originated in medical schools at Case Western Reserve University in the United States in the 1950s, and McMaster University in Canada in the 1960s. The problem-based approach was developed to improve the medical education by changing a traditional curriculum to an integrated curriculum structured by "real life" problems crossing traditional discipline boundaries. When European style formality dominated medical education, McMaster wanted to create a less stressful educational experience for students. The program they developed - problem-based learning curriculum - changed interaction between teacher-student in the classrooms. Competition changed to cooperation: one-way flow of data become a free flow of information among in class [9]. At McMaster, problem-based learning curriculum focused on two processes: first, putting students in small groups, second, providing instruction so students investigated real problems while treating real patients. Using patient records, students were supposed to determine a patient's medical problem. The questions generated as students continued diagnosis and treatment became guidelines for the course's content. The main teaching method lay in small group discussion. The most important result of McMaster's program was that lecture became discussion forums and everyone actively engaged in learning. Classes shifted their focus from facts to an emphasis on meaningful information to help solve patient's problems [10]

Table 1. Comparison of Problem-Based Learning and other instructional approaches (IIlinois Mathematics and Science Academy)

	Lecture	Direct Instruction	Case Methods	Discovery-Based Inquiry	Problem-Centered Learning	Simulation and Gaming	Problem- Based Learning
Role of student	As receiver: -Inert -inactive -Empty	As follower: -Responsive -Semi-active -waiting to be lead	As client: -Responsive -Semi-active -Applying own experience	As detective: -Picking up clues -Semi-active Seeking out evidence	As problem solver: -Evaluating resources -Crafting divergent solutions -Active	As player: -Experiencing simulation/game -Reacting to emergent condition/variables -Active	As Participant: -Actively grappling with the complexity of situation -Investigating and resolving problem from the inside
Role of teacher	As expert: -Directs thinking -Holds knowledge -Evaluates students	As conductor: -Orchestrates learning -Guides rehearsal -Evaluates students	As consultant: -Lecture pre/post -Set the environment -Advises -Evaluates students	As mystery writer: -Combines parts that lead to "discover" -Provides clues and foreshadows event -Evaluates students	As resource: -Explicitly teaches content and problem-solving -Poses problems with which students relate -Translates into students' world -Evaluates students	As stager: -Manages situation -Sets simulation /game in motion -Debriefs situation	As coach; -Presents problematic situation -Models, coaches, and fades -Engages in the process as co-investigator -Assesses learning
Role of problem	-Well-structured -Presented as a challenge to retention	-Well-structured -Presented as a challenge to retention	-Well-structured -Presented as a challenge to application and analysis	-Well-structured -Presented as a strategy for knowledge	-Moderately-structured -Presented as a strategy to develop effective learning behaviors	-Moderately-structured -Presented as a strategy to understand self and/on events	-Ill-structured -Presented as a situation within which a compelling problem is yet to be defined
Organization of information	Organized and presented by instructor	Organized and presented by instructor	Most is organized and presented by instructor	Most is organized and presented by instructor	Most is organized and presented by instructor	Most is organized and presented by instructor	Little is presented by instructor the without students identifying need. Most is collected and analyzed by students

3. Integration of Problem- Based Learning into Instruction

Finkle and Torp [11] stated that "problem-based learning are curriculum development and instructional system that spontaneously improves problem solving strategies, disciplinary knowledge-bases and skills by placing students in the active role of problem solvers who are come across with ill-structured problem". Students can face with problems as a research project, a case method, and a design project. Therefore, it is used to engage students in learning.

The relevance of problem in PBL is a primary issue according to cognitive theory. Brooks and Brooks [1] stated that, it is one of the universal principles of constructivist teaching. The problem scenario should challenge student's original hypothesis. Keller [12] states "the challenge, incongruity, anomaly, or discrepant event creates a springboard to activity based on cognitive dissonance". For example, in order to learn a new concept, students must first recognize a problem and their inability to solve it [13]. Students' inability to solve problems is due to presentation of a "discrepant event". A discrepant event is a statement or situation which creates a state of disequilibrium (or cognitive dissonance). The disequilibrium forces questioning to prevent uncertainty and enter a state of equilibrium again [14]. Therefore, it is necessary for teachers to create new frameworks for the classroom if they want to use the PBL. Savery & Duffy [15] state "students may confront with a problem. They discuss the problem, generate hypothesis, identify relevant facts, and learning issues or objectives based on their

Table 2. Tasks of Problem-Based Learning

1. Explore the problem, create hypotheses, identify issues. Elaborate.
2. Try to solve the problem with what you currently know. From this will come a clearer idea of what you already that is pertinent.
3. Identify what you do not know and therefore what you need to know because your lack of knowledge is impeding the solution of the problem.
4. Prioritize the learning needs, set learning goals and objectives, and allocate resources so that you know what is expected of you by when. For a group, members can identify which task each will do.
5. Self-study and preparation
6. For a group, share the new knowledge effectively so that all the group learn the information.
7. Apply the knowledge to solve the problem.
8. Give yourself feedback by assessing the new knowledge, the problem solution and the effectiveness of the process used. Reflect on the process.

analysis of the problem. If prerequisite knowledge relevant to problem's resolution is missing, then students are responsible for its accommodation". They also provide following suggestions for structuring a problem-based learning environment: 1) Base all learning activities to a task or problem. 2) Encourage the learner to developments ownership for the problem or task. 3) Prepare an authentic task. 4) Prepare the task and the learning environment to reflect the complexity of the environment where students should be involved in every stage of their learning. 5) Provide opportunity to give the learner ownership of the process used to develop a solution. 6) Prepare the learning environment to support and challenge learner's thinking. Encourage testing ideas against alternative views and alternative context.

The following characteristics of PBL are summarized by Bridges and Hallinger [16]. First, a real world problem is the starting point. Second, knowledge that students should obtain is organized around problems, not disciplines. Third, students have the major responsibility for their own learning. Fourth, learning occurs within the context of small groups rather than lectures. Norman and Schmidt [17] stated that there are three roles for PBL. The acquisition of knowledge, the mastery of concepts that can be used to solve similar problems, and the acquisition of prior examples that can be used in similar problem-solving situations in the future.

Using ill-structured problems is a key element of problem-based learning. Ill-structured realistic problems differ from the well structured ones in most school textbooks in several ways. Stepien et al., [18] stated some of the features of ill-structured problem. First, students need more information that is presented to them and this missing information will help them understand what is occurring and help them decide what actions are required for solution. Second, there is no right way for conducting the investigation; that is, each problem is unique. Third, the problem changes as more information is found. Fourth, students act as decision maker to solve the real-world problems.

The study of Stepien & Gallagher [19] illustrates the use of an ill-structured problem in the following scenario. Students collect information and list it under a heading entitled: "What do we know?" Under this heading students activate prior knowledge and discuss the situation. They analyze and find a problem statement. The problem statement is a starting point and may be changed as new information comes to light. Under a second

heading, there is a list termed "what do we need to know?" Here, students list questions that must be answered to find missing knowledge. The third one, "What should we do?" Students gather information from the classroom. While new information comes to light, it is analyzed for its usefulness in the problem statement. Another essential feature of PBL is student ownership. If students do not own the problem, they spend their time trying to figure out what the teacher wants. Hence, teacher should avoid giving out too much information. Doing so implies that there is a 'correct answer' and takes away students ownership of the problem. Therefore, in a PBL classroom, teachers function as metacognitive coaches; "...serving as models thinking aloud with students and practicing behavior they want their students to use" [19] (p.27). What is going on here? What do we need to know more about? What did we do during the problem that was effective? Teachers prompt students to use questions and take responsibility for the problem. Students must be given time and stimulation to find relevant information and the opportunity to modify their points of view. They also need time to think about the situation or scenario, form their own answer and accept the risk of sharing answers with peers [1]. By this way, students become self-directed learners.

Students' specific tasks in a problem-based learning environment include: 1) Determining the problem 2) Creating a problem statement 3) Identifying information to understand the problem 4) Defining the resources to gather information 5) Producing possible alternative solutions 6) Analyzing the solutions 7) Presenting the solutions orally or in writing.

Cognitive researchers and theorists suggest that cooperative learning improve concept development and problem solving. According to Piaget, the importance of peers comes from their ability to share ideas. Vygotsky argued that learning occurs in social contexts and is internalized at a later time.

He proposed a zone of proximal development*** to describe the differences between a students ability to solve a problem alone and with the help of a more "knowledge person". In addition, Tanner and Keedy [20] state "learning is a social activity and intervention of teachers should encourage the development of students meta-cognitive skills****". Problem-based learning environment directs students to study in groups and also, directs students to take help from knowledgeable person.

Advantages of problem-based learning can be summarized as follows: Improves problem solving skills, develops an effective and an efficient clinical reasoning process, integrates knowledge, maintains life-long learning, increases early clinical experience [10], increases student-faculty interaction, increases motivation, promotes meaningful learning [21], creates opportunity for critical thinking, metacognitive growth, and identifies students' learning needs [22]. In spite of advantages, there have been also some problems in implementing PBL. Students familiar with the traditional "talk and chalk" in classrooms can be uncomfortable with the PBL for awhile. Therefore, the teachers should convince students that they are researchers looking for solutions to problems that may not have one "right answer". They will expect the teacher to prescribe a number of tasks, events, and concepts. Students who adapt traditional teaching may feel uncomfortable with PBL roles when they have to do research, talk with peers, and make up unique products. If students are new to PBL, they may actually learn less at first. Becoming comfortable with PBL will take at least a year and this mode will consume more of teacher's energy. Teachers new to the PBL may give students key variables, too much information, or simplify problem for them. These are reducing the effectiveness of the PBL.

*** The difference between the difficulty level of o problem, o child can deal with independently and the level that can be occomplished with the help of more expert individuols.

**** Skills and knowledge used to regulate thinking and learning.

3.1. Integrating Problem - Based Learning Curriculum in to Science Education

Science bases on truth and factual information. Many people see science as students taking real measurements and working with this real information to learn scientific concepts, and to be involved in developing their own problem solving methods.

Studies in precollege classrooms have shown that science learning has little effect on any of the three areas of scientific literacy: understanding basic science concepts, understanding the process of science, and understanding the effect of science on society [23]. Therefore, schools need to change their approach to science education if they want to prepare citizens to make decisions on science-related issues. The curriculum must be changed so that science instruction becomes relevant in the real world. It is a good idea to approximate the processes involved as closely as possible given the ages of the learners involved.

Stepien & Gallagher [24] stated the brief steps of the scientific process: 1) Determine a good problem 2) Learn information about the problem 3) Decide which experiments, observations, and calculations can help a solution of the problem 4) Conduct the experiments, observations, and calculations 5) Decide whether the results help to a better understanding of the problem. If they do not, either go back to step two and refine your statement of the problem, so it is more tractable or go back to step three. If they do, go to step six. 6) Share your results: talk and publish. Most science programs focus only on the second and fourth items on the list, leaving out some of the most important parts of the practice of science. However, the scope of scientific reasoning reflected in the list is closely related to the reasoning students experience in problem-based learning.

The staff and practitioners of College of William and Mary found that "the problem-based learning structure could be adapted for science by ensuring the inclusion of some important components of the scientific process and by careful attention to the inclusion of science concepts" [24](p,137). Specifically, the staff identified four adaptations essential making problem-based learning reflect closely possible science practice.

1. Students focus on the problem concerning a science concept. Using that problem and the concept, students investigate the significance of science content.
2. Students have the opportunity to test their ideas experimentally. Students should generate some of the data to solve their problems themselves rather than depending on the work of others (teacher - supplied information, or information from experts and mentors).
3. Students have the opportunity to manage their own data, that is, students learn how to keep good notebooks, learn techniques to record data, save and store data.
4. Students have the opportunity to present their solutions which can be arranged in either the "talk" or the "publish" format. Groups of students present their reports orally in a conference format, develop a poster session, or put together an issue of scientific journal for distribution. Students are involved in the instructional process, respond by building their own cognitive structures which form the meaning of their world [25].

4. Current Status of PBL in Turkey

PBL studies in Turkey is mostly concentrated on the medical sciences. According to Emerk [26], PBL increases motivation, teaches how to solve problems, reinforces learning and recalling, gives responsibility to students and support learning on their own accord. Moreover, it improves communication and analysis-synthesis skills which is necessary for physicians. On the other hand, in PBL, students learn how to learn which may lead to misunderstanding and lack of know-

ledge. Emerk, stating that PBL provides integration of general science disciplines into medicine, believes that it should be adapted into Turkish Education System and implemented in our curricula considering not only at the university but also the lower grades. Kırkalı [27] stresses the role of educator in the PBL sessions. She defines the educator as an important element of PBL and suggests that educator should be a catalyst rather than being a substrate in active education.

Many of the seminars and symposiums done in Turkey revealed that there is a general consensus concerning the replacement of teacher-centered methods with student centered one. For example, the curricula of the Faculty of Medicine in the University of 9 Eylül was shifted from traditional approach to the problem-based system which has started to be implemented in the 1997-1998 academic year [28]. Aims of this system include acquisition of knowledge, attainment of cognitive, communication and clinical skills, acquisition of professional values and grasp the medical issues from ethical perspective. Major characteristics of the curricula can be summarized as follows: society-based, integrated education, student centered, problem-based, competency-based. Güner [28], who evaluated the problem-based active educational system in the University of 9 Eylül, suggests that PBL applied to biochemistry courses increases motivation, provides better retention, improves the use of knowledge, and eliminates student's conflict about how to use their already existing knowledge.

5. CONCLUSION

One approach reported in the education literate that enables students to utilize both their knowledge from various sources and to develop their reasoning skills within a discipline area is problem -based learning [29, 30]. This approach moves education just from teaching information by teacher, to a situation where the learning is student-centered with students exerting much more control over the learning to be completed [22].

Problem-based learning is an instructional method that challenges students to "learn to learn", working cooperatively in groups, to seek solutions to real world problems. It is one of the most suitable ways for students to engage in real life problems. These problems are used to engage students' curiosity and initiate learning the subject matter. Students are given ill-structured problems and do research into them.

While researching the solution they learn science concepts and also, concepts of the other disciplines. In addition, they choose relevant data to reach to the result. Students engaged with these kinds of problems simultaneously improve their problem solving skills. As we know, one of the most important goal of the science education is to educate student to be able to construct own ideas and solve problems accordingly. Therefore, as science educators, problem-based learning should be our primary guideline in instruction.

We believe PBL promises to improve the students' critical and analytical thinking at all levels of schooling from kindergarten to grade twelve and can be readily adapted to any subject area or discipline. Therefore teachers and educators should take PBL into consideration inorder to improve the curriculum and instruction in science education and develop new science instruction models and put into practice.

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