The effects of problem based learning on cognitive flexibility, self-regulation skills and students' achievements

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Abstract

The purpose of this study is to specify the effects of cognitive flexibility and self-regulation skills on students' achievements in web mediated problem based programming language learning towards gender and class groups. Self-regulation skills towards web based programming language education is discussed under three dimensions; learning skills, learning strategies and self-efficacy. Level of cognitive flexibility is reviewed by comparison of time and percentage of success. Causal-comparative research model is used in this study where five different class groups are compared in. Furthermore, a web based problem was given to this students and their success is calculates as the grades that they get from each step. As a result, this paper indicates that when the correlation between level of cognitive flexibility and students' achievements is taken under consideration it is seen that there is a positive linear relationship between them. It can be said that students who have higher cognitive flexibility level also have advanced problem solving skills.

Keywords: web-based learning; problem-based learning; cognitive intelligence, self-regulation

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1. Introduction

Educational improvements are changing in the way teaching and learning process occurs. Today teachers concentrate on how to teach instead of what to teach. Students being expected to gain process skills in their classes and having the responsibility for learning, a change of direction is required that from the teacher centered learning to student centered learning. Thus teachers primarily responsibility is to help students to reach learning goals rather than being reach the source of knowledge [1].

In today's information societies, it is not only expected that students gain information but also use this gained information in solving complicated problems [7]. Therefore, students should also be taught the source of information and how they can gain this information, how they can evaluate it and how they can use this information in solving problems. Concordantly, problem based education assumes an important role in attributing these characteristics to individuals.

Almost every day our lives are deeply affected by many problems. In these situations, what we want is to immediately remove this problem. However, this desire only is not enough. The way we reach the point of solution of the problems and our individual development is significantly important [21].

Students solve problems and reflect on their practices in problem-based learning (PBL), which is a student centered didactic strategy. PBL highlights critical thinking and problem solving skills with students [16]. PBL turns instruction upside down. Students encounter an "ill structured problem" before they receive any education [8, Teo and Wong (2000) stated that PBL is one of the most effective methods used in especially science teaching. Peterson and Treagust (1998), Siegel and Lee (2001) also stated in their research that PBL is an effective approach for teaching science.

Problem based education represents a new paradigm in the learning-teaching process. With problem-based learning, students can discuss questions with each other, offer solutions, and share results. The combination of online discussion and problem-solving activities can establish a problem-solving-based online discussion learning activity. Within the activity, teachers can define the scope of the problem and allow students to raise various questions among themselves. After that, students can collect information from the Internet and discuss possible solutions on the internet. This encourages students to solve various problems and construct their knowledge. During the process, teachers will provide adequate guidance to improve the quality of students' discussion [9].

2. Background

Problem Based Education is an approach that aims to ensure students to think deeply by leaving them face to face with a well-structured problem they may encounter during real life and provide the sources and guidance they may require, thus enable them to learn on the issue on their own during the problem-solving phase and gain problem-solving skills [2].

Problem based learning is an approach with which students learn by using their experiences and their experimental findings they obtain by considering the tasks that occur with a specific problem situation (Torp and Sage, 2002).

The cognitive flexibility theory comprises of the transfer of information and preliminary information. Thus, the students learn fundamental concepts and theories with linear content. When there is advanced information gaining, a non-linear approach constitutes the base for learning of an ill-structured area [19]. Therefore, it could be said that cognitive flexibility is involved with complicated structured being presented more flexibly and personally, not with a strict content. PBL is a powerful instructional method. Learners can be encouraged to play an active role to use high level cognitive thought processes to solve problems and to struggle for investigation and inquiry by working through some difficult problem-solving tasks [18].

Self-regulation refers to the use of processes that activate and sustain thoughts, behaviors, and affects in order to attain goals [15] Today, with the help of these self-regulation skills such as self-observation, self-judgment and self-reaction problem-solving strategies are used in almost every field from medicine to literature and from history to economics.

In addition to these skills and behaviors, there are more important points in learning. According to Dennen [6] one of the factors that affect learning is how to know who is actively contributing to the assignment and how to make sure that all students have the opportunity for substantive input were some issue that instructors who assign group projects have. There are lots of reasons to say that an online collaborative learning environment is found appropriate for facilitating group projects. To name a few, it was a way of extending the students' growing computer skills and literacy, it provided a glimpse of a new technology that could be used for learning and instructor recognized that it held the potential for promoting more collaborative and successful group projects.

Problem based learning environments offer students an opportunity to implement what they have learned. Organizing information and materials and presenting them gives students a better opportunity to use their high level thinking skills more when compared to conventional learning environments. Problem based learning, which is one of the fundamental approaches of the constructivist approach, directs the students the thing, question and discover [22].

Lavasani, Afzali and Afzali [11] indicated that cooperative learning method in comparison with traditional method is of a much higher effectiveness on the social skills of students. Problem based learning develops cooperation based learning. Students develop their skills by using problem based learning, solving the problems with teamwork and by learning from each other. Each student in the team can work on a different aspect of the problem. Furthermore, they also develop their leadership by taking on tasks in their own team or helping the other students [5].

Over the past few years, PBL has been used in many various areas like medicine, architecture or chemical engineering and successfully applied in different learning environments. This approach is formed to create problems to learners so that by developing solutions they can learn about a particular area [12].

All learning in problem-based instruction stems from students initial questions about a problem situation [8]. The problem based learning process starts with presenting a problem suitable within the framework of the students' field. A connection between the problem and real life is established. The issue is constructed with regard to the problem. Then the students are taken the responsibility of learning own by teamwork. Students are encouraged to work together and present their products of learning to the class and discuss them [14].

Most PBL definitions have four common elements [10]. These are:

- The learning objectives are turned into a problem,
- They require perfect solutions, possible solutions and behavioral preferences, and an explanation,
- Students use small group debates in order to analyze the problem and its potential solutions and to understand it,
- Questions or situations that cannot be answered within group debates constitute a base for outer-group future learning.

While Torp and Sage (2002) divide the process into two as "Problem Design" and "Problem Application", according to Barrows' this process is constituted by four stages as listed below;

- First Stage; students discuss what they know and what they don't, they form a hypothesis and then the issue starts to clarify as a result of the discussions. In addition to this, students gain the skill to criticize their classmates' comments.
- Second Stage; students work on it and make their plan active. They put forth how they are going to learn the information and skills that they do not know. The

sources that are required are determined during this stage. During this stage, students will have taken a big step in learning on their own.

- Third Stage; in this stage, students use the information that they have gained to accept or to object to the hypotheses that they have formed. They get an idea of which research methods are productive, which sources are useful and which research methods and sources are necessary by criticizing the methods and sources.

- Fourth Stage; during practice, students summarize what they have learned and then discuss how they can use this information and these skills in the future. Consequently, students reflect what they have learned by integrated with it.

Table 1: Traditional Learning Strategies and Problem Based Learning Strategy (Torp & Sage, 2002)

Learning Strategy	Objective	Teacher's Role	Student's Role	Information
Direct Learning Strategies	Ensuring that students exactly repeat the information they have learned when requested	1. The teacher, as the expert, possesses the information and directs the students' thinking 2. The teacher, as the controller, directs the students' learning and evaluates the students	1. The student, as receiver, is passive and perceived as an empty tank. 2. Students, as a follower, waits upon the leadership of the teacher	The information is organized by the teacher and then presented to the students
Problem Based Learning Strategy	Enable students to establish their own knowledge so that they can find a solution in a problem situation	1. The teacher, as a cognitive guide, present the students with a problem, 2. The teacher as a source, directs questions to the students, establishes relationships with the students' world and directs the students' learning	1. Students, each as a problem-solver, produce various suggestions for solutions to problems they encounter by using the available sources. 2.Students, each as a participant, are active in the learning process and internally research the problem	A very little amount of information is presented by the teacher; the greater part, however, is collected and structured by the students.

3. Research Question

In programming language education, how does the web assisted problem based learning approach affects students' achievements, their level of cognitive flexibility and self-regulation skills?

4. Methodology

4.1. Research Model

Within this research a comparison of cognitive flexibility with regard to gender and self-regulation skills is discussed and it is analyzed whether there is a significant difference in achievement of courses for C# (programming language) in computer assisted problem based learning approach. In this regard, cognitive flexibility is specified as dependent variable and achievement of courses is specified as independent variable.

In this research, "Cognitive Flexibility Test", which is a web-based test application design by department of Psychiatry at the University of California, is used in order to determine how the flexibility differs from one student to another and "The Scale of Self-Regulation Skills Towards Web-Based Education" is also used which is a five point likert scale and made up of 64 items [3]. Furthermore, students are asked to develop a "one way messenger application".

4.2. Study Group

The study is carried out in Bahçeşehir University. The study is carried out with second-year and third-year undergraduate students who are taking course of C# which is lectured at department of Software and Computer Engineering in Engineering Faculty. The research is carried out on the whole students taking course of C# in spring term of 2010-2011 academic years. These participants, who composed the working group, are subjected to the scale of self-regulation skills towards web-based education and a brain test is applied in order to measure cognitive flexibility. The participants composing the working group are made up of 5 groups that are including 49 male and 26 female in total. Student distribution for the first group is 15 students, for the second group 14 students, for the third group 14 students, for the fourth group 14 students and for the fifth group 18 students.

4.3. Data Analysis

In the statistical analysis of the data, in order to compare the flexibility level and self-regulation skills of students according to their genders, independent-samples t-test, to compare the attitudes and views of students when different groups are considered, one-way analysis of variance (ANOVA) was used. Moreover, correlation coefficient was used in order to interpret the relationship between students' success in C# towards PBL and their flexibility level. The statistical analyses were done on SPSS 17.0.

5. Results

5.1. Results of the Scale of Self-Regulation Skills towards Web-Based Education

ANOVA analysis is done using the scores that participants achieved in the scale. However it is concluded that there is not a significant difference between groups ($F_{10,35}=.97$, $p>.05$) and genders in terms of self-regulation skills towards web-based education. Accordingly, we can say that the relationship between gender and students' self-regulation skills towards PBL is not statistically significant at the level of $p<.05$.

5.2. Results of Cognitive Flexibility Survey

As a result of the analysis carried out at a significance level of .05, a significant correlation between students' cognitive flexibility and success could not be ascertained (.620; $p>.05$). When the percentage of success that students achieved in cognitive flexibility test and the average scores that students achieved in scale of self-regulation skills are used, it is concluded that at significance level of .05 (.557; $p< .05$), a significant correlation between students' cognitive flexibility and self-regulation skills could not be ascertained. Also it can be deduced that the correlation between gender and cognitive flexibility is statistically insignificant.

5.3. Results of Cognitive Flexibility & Students' Success

In the web-based problem that is made up for students to solve, students are supposed to write a phonebook software. Students send the code that they have written regarding to the problem to their lecturer via web environment. The lecturer prepares a template so as to evaluate the problem and defines the total score summing up the points that each student achieved from each step. In terms of determining to what extend efficient is students' cognitive flexibility in solving problem, the results of cognitive flexibility test and the points that students achieved in each step of a sample problem which they solved are compared. When the Table 2 is examined, it is seen that there is a positive linear relationship (.000; $p<.01$) at 0.01 level of significance in steps {2, 3, 4, 8, 12, 13, 14, 15}, and also there are positive linear relationship (.001; $p<.01$) in order in both cases at 0.01 level of significance in 1st step.

According to Table 2, it can be said that there is a positive linear relationship between cognitive flexibility and writing properties and constructors dependent to classes. When we look

at the steps that have positive linear relationship, we can say that students who have higher cognitive flexibility level also have advanced problem solving skills. Students, who are successful through the necessary algorithm steps to solve the problem, are more successful than other students in the flexibility test and it is seen that they fulfil successfully the underlying programming steps.

Table 2: Correlation between students' level of cognitive flexibility towards algorithm logic

		P	Pearson Correlation
1	Giving Proper Control Names	.001	.387[**]
2	Writing the properties of MessageList Class	.000	.396[**]
3	Writing the Constructors of MessageList Class	.000	.507[**]
4	Writing the ToString() and the MessageInfo() function in MessageList Class	.000	.507[**]
5	Writing the properties of Contact Class	.219	.144
6	Writing the Constructors of Contact Class	.219	.144
7	Writing the ContactInfo() function in Contact Class	.700	.045
8	Writing the ReturnMessages() function in Contact Class	.000	.620[**]
9	Writing the Form_Load Event	.	.[a]
10	Fill Add Contact Button Click Event	.727	.041
11	Increase Contact Counter Automatically	.827	-.026
12	Fill Send Message Button Click Event	.000	.734[**]
13	Fill Selected Index Change Event	.000	.746[**]
14	Fill Delete Button Click Event	.000	.608[**]
15	Fill ContactInfo Button Click Event	.000	.443[**]

6. Conclusions

There are some studies that provide valuable insights on new and effective technics and practices for both schools and teachers who are currently implementing or planning to implement online learning. Also they provide different ways of increasing students' interests and helpful references to ways of helping online students regulate their learning [13]. PBL is a well-known learning method with several alternatives, however the general approach consists of student-centered, small group and activities of problem-focused learning [4].

The general aim of this research is to determine the effects of the level of cognitive flexibility in problem based learning on the success rate and self-organization skills of student. The answers of the below listed questions were searched in line with this objective.

- Is there a difference between groups in terms of self-organization skills with regard to web based learning?

- Is the success rate of students that have a higher cognitive flexibility level, higher than students that have a lower cognitive flexibility level?

- Are the self-organization skills of students with high cognitive flexibility levels higher than students with low cognitive flexibility levels?

- Does the level of cognitive flexibility vary according to gender?

- Learning will be more permanent in students that have a higher level of cognitive flexibility when compared to students with a low cognitive flexibility level.

- Is the algorithm logic and qualities of the steps that need to be taken during problem-solving in problem based learning for students that have a high level of cognitive flexibility more comprehensive than those of students that have a low level of cognitive flexibility?

According to this result, it can be said that C# course, in which PBL method was applied, it has a positive effects on students' achievements. Through the analyses carried out, 6 sub

problem sentences are tried to be answered. As a result there is no difference between class groups in terms of the self-regulation skills towards web based learning and level of cognitive flexibility. Similarly there is also not significant difference between genders in terms of self-regulation skills towards web based learning and level of cognitive flexibility.

6.1. Recommendations on Future Researches

- -The impact of problem based education on student success can be analyzed grouping participants into two that are receiving web based education and that are not receiving web based education.

- The correlation between cognitive flexibility and different approaches, educational environment in different schools can be analyzed.

- The correlation between self-regulation skills and different approaches, educational environment in different schools can be analyzed.

- A web based environment can be developed to increase cognitive flexibility and also contribution of this web based environment into increasing cognitive flexibility can be analyzed.

- Effects of cognitive flexibility levels on interface design with web based environment can be analyzed.

- In programming language teaching, analysis and designof software interfaces depending on the age ranges of the process of cognitive flexibility can be searched.

- Different scientific field studies which analysis the relationship between self regulation recovery and cognitive flexibility level can be planned.

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