IMPLEMENTATION OF THE PROBLEM-BASED LEARNING (PBL) IN THE UNIT OF GENETICS

Araz, Gülsüm arazg@metu.edu.tr
Sungur, Semra ssungur@metu.edu.tr

Abstract

This study aimed at investigating effect of problem based learning (PBL) and traditional lecture based instruction on elementary school students' academic achievement and performance skills in the unit of genetics. A total of 217 eight grade elementary school students in Turkey participated in the study. The PBL instruction was based on ill-structured problems. While dealing with these problems, students did independent study as well as group work. On the other hand, traditional instruction was based on teacher explanations and textbook. Multivariate Analysis of Covariance results showed that students in PBL classes had higher mean scores on Genetics Achievement Test developed to measure academic achievement and performance skills in the unit of genetics. Students' reasoning ability and prior knowledge were used as covariates in the analysis.

Theoretical Framework

PBL provides students with guided experience in learning through dealing with ill-structured problems reflecting the real world. Results of studies in the literature, which implemented in elementary and high school settings, revealed that the PBL creates an environment in which students actively participate in the learning process, take responsibility for their own learning, and become better learners in terms of time management skills, ability to define topics, ability to access different resources, and ability evaluate validity of these resources. Moreover, it was found that PBL appears to improve critical thinking, communication, mutual respect, teamwork, interpersonal skills and increase students' interest in the course and make students apprentice scientists. Furthermore, it was suggested that PBL encourages students to identify knowledge deficiencies, coordinate actions and people, realize goals and continuously monitor understanding (Galand, Bentein, Bourgeois & Frenay, 2003; Karabulut, 2002; Paris & Pairs, 2001).

However, it should be noted that regardless of which instructional approach is employed in the classrooms, students' prior knowledge has great influence on their further learning. In fact, Ausubel (1968) proposed that students learn meaningfully by constructing new knowledge on the basis of what they already know. In addition, since understanding of genetics requires an abstract level of thinking, it is necessary to consider students' reasoning abilities while predicting their genetics achievement. Actually, Lawson and Thompson (1988) reported that in order to overcome prior misconceptions and establish scientifically acceptable biological conceptions concerning genetics and natural selection, formal reasoning ability was necessary for seventh-grade students. Therefore, in the present study, students' reasoning ability and prior knowledge were used as covariates to control the variance in achievement and performance skills scores due to these variables.

Method

Sample

- Participants of the study were 217 eight grade students (99 boys and 118 girls).
- Students attending an elementary school in an urban area in Turkey.
- The mean age of the students was 14.08 years (SD=0.36, range 13 to 15).

Instrument

- Genetics Achievement Test (GAT):
  The test developed by the researchers. It was administered before and after treatment to measure students' academic achievement and performance skills respectively. Pretest scores were used as covariates. Internal consistency reliability coefficient was found as 0.63 for this sample.
  - Multiple Choice Items: The test included 20 multiple- choice items related to Mendelian Genetics.
  - Essay type item: Essay type item prepared in accordance with problem based learning approach aimed at measuring students' performance skills such as ability to use of relevant information in addressing the problem, articulate uncertainties, organize concepts, and interpret information.
- The Test of Logical Thinking (TOLT):
  It was developed by Tobin and Capie (1981) to measure the formal reasoning ability of students. The test consists of 10 items. Students respond to each item by selecting a response and a reason for selecting that response. For an item to be scored correct, the student must check the best answer and the best justification. The Cronbach alpha internal consistency for the test was found to be r = 0.85.

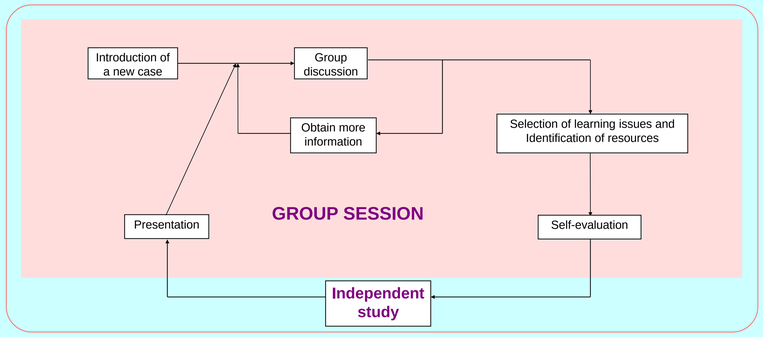
Treatment

This study was carried out during 2005-2006 fall semester. The topics related genetics were covered as part of regular classroom curriculum in the science course. The classroom instruction was four 40-minute sessions per week.

Small group work	In the PBL classes, small heterogeneous groups were formed so that interaction among students with different learning styles, academic performance, and gender was optimized.
Ill-structured problem and generating ideas	Groups dealt with ill-structured problems related to Mendelian Genetics. Problems were introduced to students as cases and case information was distributed over several pages and presented one at a time. In this way, increasing amount of information about the problem was provided to students as they needed. Students brainstormed and generated ideas and hypotheses related to the problem and identified the learning issues.
Independent study	Then, each student in a group conducted independent study outside the classroom. Purpose of the independent study was to seek for information regarding learning issues in relation to problem situations.
Sharing the information	Next, in the classroom, students shared the information that they acquired during independent study with other students in their groups. Students discussed new knowledge and revised their previous ideas, hypotheses based on new knowledge. These processes continued until the groups thought that sufficient basic science was learned.
Teacher's role	Actually, during these processes, teachers acting as facilitators stressed that purpose is not to find a quick solution to problems but to learn about underlying concepts and principles.

On the other hand, in the traditional classes, instruction was based upon lessons with lecture/questioning methods and teaching strategies depended on teacher explanations, discussions and textbooks.

PBL Process



Results

Multivariate Analysis of Covariance was conducted to investigate relative effect of the PBL and traditional instruction on elementary school students' academic achievement and performance skills in the unit of genetics while controlling for prior knowledge and reasoning ability. Results showed a statistically significant mean difference between the PBL and the traditional classes with respect to the collective dependent variables of academic achievement and performance skills, $F(2, 211)=5.99$, $p=0.003$ (Table 1).

Univariate ANOVA results for each dependent variable further indicated that there were significant mean differences between two groups with respect to each of the dependent variable ($p < 0.05$). When the mean scores on academic achievement scores and performance skills scores were examined, it was found that students in the PBL classes had higher mean scores ($M = 11.44$ and $M = 2.67$, respectively) compared to the students in the traditional classes ($M = 10.91$ and $M = 2.20$, respectively).

So, PBL students appeared to have higher levels of academic achievement and higher levels of performance skills. In addition, results showed that there was a significant relationship between reasoning ability, prior knowledge and collective dependent variables ($p < 0.05$) (Table 2).

Table 1: Results of MANCOVA

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Intercept	Wilks' Lambda	,473	117,654(b)	2,000	211,000	,000	,527
Reasoning Ability	Wilks' Lambda	,867	16,185(b)	2,000	211,000	,000	,133
Prior Performance Skills	Wilks' Lambda	,904	11,214(b)	2,000	211,000	,000	,096
Prior Knowledge	Wilks' Lambda	,919	9,328(b)	2,000	211,000	,000	,081
GROUP	Wilks' Lambda	,946	5,989(b)	2,000	211,000	,003	,054

a Computed using alpha = ,05
b Exact statistic
c Design: Intercept+ Reasoning Ability + Prior Performance Skills+ Prior Knowledge+GROUP

Table 2: Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	F	Sig.	Partial Eta Squared	Observed Power(a)
Reasoning Ability	Performance Skills in Post-test	4,816	1	2,655	,105	,012	,368
	Post-Knowledge	269,636	1	32,506	,000	,133	1,000
Prior Performance Skills	Performance Skills in Post-test	40,868	1	22,529	,000	,096	,997
	Post-Knowledge	14,406	1	1,737	,189	,008	,259
Prior Knowledge	Performance Skills in Post-test	4,353	1	2,399	,123	,011	,338
	Post-Knowledge	153,955	1	18,560	,000	,080	,990
GROUP	Performance Skills in Post-test	10,481	1	5,778	,017	,027	,667
	Post-Knowledge	76,975	1	9,280	,003	,042	,858
Error	Performance Skills in Post-test	384,580	212				
	Post-Knowledge	1758,538	212				
Total	Performance Skills in Post-test	1774,000	217				
	Post-Knowledge	29745,000	217				

a Computed using alpha = ,05
b R Squared = ,145 (Adjusted R Squared = ,129)
c R Squared = ,274 (Adjusted R Squared = ,260)

Educational Importance

Present study aimed that determining relative effects of PBL and traditional instruction on students' academic achievement and performance skills while controlling for prior knowledge and reasoning ability. Results showed that, students instructed by the PBL had higher mean scores on the genetics achievement test aimed at measuring academic achievement and performance skills. Many of the multiple choice items measuring academic achievement on the test were on comprehension level and above in Bloom's taxonomy. For this reason, students had to realize interrelationships among the concepts and apply their knowledge about genetics to be able to respond to the items correctly. Moreover, essay type item measuring performance skills required students to identify relevant information in addressing the problems, use and interpret the information and take different viewpoints into consideration. Therefore, it appeared that students instructed with the PBL approach could better integrate and organize the knowledge. Accordingly, it is suggested that the PBL classes encourage students to apply their newly constructed knowledge and to take alternative point of views and strategies into consideration. Actually, Karabulut (2002) proposed that the PBL allow students to take responsibility for their own learning promoting time management skills, ability to identify leaning issues and ability to use variety of resources.

However, at this point it should be noted that in the implementation of the PBL, the basic assumption is that students' prior knowledge has influence on what they will learn and meaningful and long-lasting learning occurs when knowledge is constructed by the students (Rivarola & Garcia, 2000). Actually, in the present it was found that there was significant contribution of prior knowledge on students' academic performance in the unit of genetics. Therefore, it appeared that for dealing with ill-structured problems effectively, an extensive knowledge base was necessary for the PBL students (Gick, 1986). Moreover, current study revealed that formal reasoning was a significant predictor of academic performance. Thus, it was suggested that while preparing the PBL units, students' reasoning abilities should be taken into consideration especially for abstract topics such as genetics

In summary, PBL approach allows students interact with their environment, with their peers and in a typical PBL class, students work in groups cooperatively which allows evolvement of knowledge through social negation. Moreover, ill-structured problems posed to them lead students to apply their newly constructed knowledge and to take alternative point of views and strategies into consideration. Development of such skills as critical evaluation and acquisition of new knowledge interacting with the environment encourages life-long learning (Curry, 2002; Nowak 2001; Walton & Mathews, 1989)

References

Ausubel, D. P. (1968) *Educational Psychology, A Cognitive View* New York: Holt, Rinehart and Winston.
Curry J. J. (2002) *Problem-based learning pathway student handbook*, The Ohio State University, College of Medicine and Public Health.
Galand, B., Bentein, B., Bourgeois, K., & Frenay, E.M. (2003) *The effect of PBL curriculum on students' motivation and self-regulation.* Biennial Conference of the European Association for Research on Learning and Instruction, Padova, Italy.
Gick, M. L. (1986). Problem-solving strategies. *Educational Psychologist 21*, 99-120.
Karabulut U.S. (2002) *Curricular elements of problem-based learning that cause developments of self-directed learning behaviors among students ad its implications on elementary education*. Doctoral Thesis, The University of Tennessee, Knoxville.
Lawson, A. E. & Thompson L. D. (1988) Formal reasoning ability and misconceptions concerning genetics and natural selection, *Journal of Research in Science Teaching, 25*, 733-746.
Nowak J. A. (2001) *The implications and outcomes of using problem-based learning to teach middle school science*. Doctoral Thesis, Indiana University, Indiana, USA
Paris, S. C. & Paris A. H. (2001) Classroom Applications of Research on Self-Regulated Learning, *Educational Psychologist. 36*, 89-101.
Rivarola, V. A., & Garcia, M. B. (2000). Problem-based learning in veterinary medicine: Protein metabolism. *Biochemical Education, 28*, 30-31.
Tobin, K. G. & Capie, W. (1981) The development ad validation of a group test of logical thinking. *Educational and Psychological Measurement, 41*, 413 - 423.
Walton, H. J., & Mathews, M. B. (1989) Essentials of problem-based learning, *Medical Education*. 23, 542-558.