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RESEARCH ARTICLE

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Web-mediated problem-based learning and computer programming: Effects of thinking style on academic achievement and attitude

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Abstract

The present study aims to investigate the effect of the thinking styles on students' attitudes toward problem based learning, web based learning and academic achievement within an online problem-based learning environment. In this study, a single-factor, pre-test post-test single group and semi empirical pattern was utilized. The study was conducted on 41 students from a public university in Turkey. To implement problem-based learning activities, a teaching environment was designed with the Moodle platform, allowing for group work and discussions. Six status of the problems were prepared exclusively for the 10-week application period so that students could make suggestions about how to solve them. In the data collection phase, the Scale of Thinking Styles, the Attitude toward Problem Based Learning Scale, the Attitude toward Web Based Learning Scale, and the Academic Achievement Test were employed. *T*-test and covariance analyses were carried out in the statistical analysis phase. According to the findings of the present study, the Elaborator, and the Extrovert students have a more positive view of problem based learning than the Integrator and the Introvert students. Furthermore, the Elaborator and the Innovative students have a more positive view of web based learning than the Integrator and the Traditionalist students. Moreover, it was determined that the Elaborator and the Innovative students were more successful than the Integrator and the Traditionalist students. As a result, students' thinking styles are related to attitude and academic achievement.

KEYWORDS

academic achievement, attitude toward programming, blended learning, problem-based learning, thinking style, web-based learning

1 | INTRODUCTION

Problem Based Learning (PBL) is an experiment based learning based on solving and researching complex and real life problems [[49]: s.15]. In this method, teachers are not considered as solely people who transfer information to student directly; instead, they are mentors who guide students toward a solution to the problem. Student centered active learning in which instructors are mentors has been a focal point of modern education systems. Constructive instructional design consists of reproducible and feasible techniques that lead to learners' cognitive learning strategies and critical

thinking skills [35]. The PBL model transforms students from passive information receptors into active, self-learning, and problem-solving individuals. What is expected from education is to ensure that individuals become problem solvers in their real lives [10,60,32,17]. Active learning is a process in which students take responsibility for their own personal learning. Learning becomes a personalized process, rather than one of formal teaching, so that students' problem-solving skills, critical thinking, and learning skills can be enhanced.

In the PBL model, the concepts, learning objectives, and status of the problem are first determined. Students are informed about the basic elements of PBL before it is used. Then, students are divided into small groups. Students are given the opportunity to investigate and to understand the problems posed. Students can make suggestions regarding a solution if they are able to collect adequate information about the issue. If they are not sufficiently knowledgeable, they are encouraged to carry out further research by utilizing various data resources. All information collected in this process is shared and discussed among and assessed by group members. The suggested solutions are presented to other groups. All information regarding the problem is obtained through further discussion of results under the supervision of the teacher [20,21]. Hence, educational programs have shifted from a focus on teaching to a focus on learning. This model motivates students to learn new information when they face new problems.

In the research, [73: s.245] describe the style of thinking in which the effect of the PBL is investigated, as "a preferred way of doing things or thinking, and a preferred way for an individual to use his/her capacity." According to [57] individuals have a style profile, but not one style, although they do not depend on any profile. Styles may change to suit different tasks and situations [12].

There are many differences that affect the learning behavior of the students. The learning styles of the students (cognitive styles, learning styles, and thinking styles) are the leading in the individual differences, which affect the learning in the learning process [12]. There are some differences between these styles and skills. Sternberg [57] defines the skill as "the thing that an individual can make" and defines the style as "the choice of the individual related with the skill usage form." The thinking style is the way, which an individual prefers in using his talents. The thinking styles are not classified as good or bad, only their differences may be mentioned [56] and they are the approaches and inclination which the individuals present as the result of the mental processes against various problems, cases, phenomenon, and variables confronted by the individuals. The individuals think different from each other in the solution of a problem or in a situation which they need to make a decision and they seek different solutions. They use some of them in upper level and some of them in lower level according to the special cases.

There are many style theories, which are suggested as the result of the studies made by the researches for describing the thinking form of the people [33]. The thinking styles, which are suggested by [57] for Mental memory theory, are taken as the basis in this study. Thirteen thinking styles under five factors and its basic characteristics are as follows [57].

Thinking styles		
Dimensions	**Sub dimensions**	**Characteristics**
Functions	1. Law maker	They are innovative, generate ideas, and prefer unstructured problems. They are focused on planning designing and formatting.
	2. Judgmental	They are focused on evaluation, judgment and comparison. They evaluate rules and procedures; compare incidents and phenomenon and analyse them.
	3. Executive	They follow given instructions. They prefer to implement processes in the same way they have been done so far.
Forms	4. Progresser	They very well concentrated on what will implement; and they work by determining their priorities on majority of their assignment.
	5. Singularist	They focus on doing single task and dedicate all of their energy to this task.
	6. Pluralist	They perform multiple works at the same time without determining their priorities.
	7. Anarchical	They evaluate problems arbitrarily. They tend to focus on relax and flexible works instead of planned and systematic tasks.
Levels	8. Elaborator	They focus on tasks which require them to work by concentrating on details. They tend to perform their assignments based on concrete opinions.
	9. Integrator	They prefer to concentrate on theoretical opinions and whole concept of an opinion. They are interested in abstract thoughts and general framework.
Tendencies	10. Innovative	They prefer to deal with in determined in definite works; they are innovative and visionary.

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Thinking styles		
Dimensions	**Sub dimensions**	**Characteristics**
	11. Conservative	They are traditionalists, realist; and they are attached to the codes relevant with their works.
Inclinations	12. Introvert	They prefer to work alone; they are self-sufficient and less social.
	13. Extrovert	They prefer works require cooperation. They enjoy establishing relationship with others.

In this study, the dimensions of levels, tendencies, and inclinations were discussed.

Instructors could create learning environments to allow them to gain the capacity to develop different point of views and to increase their effectiveness in discussions [64]. Playing an active role in learning environments and actively participating in courses both make students more academically successful. The transition from the instructor-centered teaching to student-centered teaching has been fundamentally based on this idea. The active usage of computers and the internet in education and training activities contributes positively to the interaction between instructors and students and to student achievement. As mentioned by [14], the usage of the learning environment which provides opportunity to the students for using their thinking styles, shall develop the critical thinking skills and high level problem solving skills. Educational activities can be helpful tools for individuals to develop better styles of thinking with regard to problem solving [22] and individuals' preferred intellectual styles could change [26].

According the literature, thinking styles affect the motivation and academic success of the student [14,44,71]. In addition to this, it is seen that the various demographic features predict the thinking styles [58,68,69]. For example, the results which examine the thinking styles, social skills and the relation between their attitude for some learning environment and the learning methods in terms of various variables [22,67,45,5] have effect on the thinking styles.

In the present study, a Computer Programming course was investigated in terms of the PBL thinking styles. Computer programming has become one of the more prominent professions today due to the significant growth in the Information Science industry. Programming courses are some of the subjects which students find most difficult to understand [4,7,43,47]. Achievement in computer programming depends on individual's problem solving, logical, and numerical thinking skills [41,39]. In addition, the reason for the academic failure of the students' programming languages are the "learning strategy," "lack of practice," "inadequate study," "subject difficulty," "lack of effort," "appropriate teaching method," "test anxiety," "inadequate time," and "faulty approach" [31].

According to the relevant literature, various methods, and techniques have been applied to enhance efficiency in programming education. To make programming education more simple and interesting, there have been various prominent applications such as the development of the "Edujudge" e-learning platform [63], implementation through and interactive game-based approach [48], application through a system in which a cooperative teaching method is utilized [34], support using online forms [53], application by increasing the evaluation range [9], performing group code monitoring [65], implementation of evaluation by means of interviews with students based on stories [31], investigation based on learning styles [41], application of a virtual reality environment [27], and support using a cellular robot and similar tools [46]. Consequently, Abdul-Rahman and Du Boulay [1] who have examined the learning approaches and Tekedere and Mahiroğlu [59] who have examined the locus of control mention, it is necessary to examine the different individual characteristics on success and motivation.

No study has so far been carried out, which investigates PBL in terms of the thinking styles used in programming teaching, which requires both problem solving and high-level thinking skills. An investigation of the teaching process as it is used in programming education that are some of the subjects which students find most difficult to understand [4,7,43,47], the method and techniques employed, and the reasons for achievement or failure will contribute to the literature. In this sense, it is considered that the present study could guide teachers and instructors in terms of which programming education method should be followed for what is one of the most difficult courses to teach.

The reason for examining PBL and thinking styles in programming education is that all three concepts have some common points, as indicated later:

The objective of PBL is to enhance students' problem-solving and thinking skills [23]; programming teaching require superior problem-solving skills [41,29,37,51].

The essential objective of PBL is to be a model which assists students to gain the capacity of versatile thinking and problem-solving skills [18]; in the executive thinking style,

individuals are make, apply, and execute and prefer pre-configured problems [57].

In PBL, learning is maintained on the basis of a problem [6,66], in the law maker thinking style, the individual enjoys creating problem solutions and planning [57].

In PBL, students actively participate in learning and take more responsibility [8,49], extrovert students are more likely to collaborative than introvert student [57].

Assessment of all the information obtained in the PBL process by sharing and discussing it among the group members, and discussing the results obtained in relation to the problem situation under the guidance of a teacher, and allowing [20,21] the students who use the extroverted thinking style to enjoy group or cooperative learning [71].

Thinking styles are the approaches and inclination which the individuals present as the result of the mental processes against various problems, cases, phenomenon, and variables confronted by the individuals [56]. The earlier explanations regarding the variables and the relationship among them reveal that it is necessary to investigate whether the thinking styles adopted by students are determining factors in learning programming languages through the online PBL method.

This study will contribute significantly to the literature by considering the fact that the thinking styles can be changed depending on the culture, the time and the situation in a strictly social relation with the social environment [[56,57,70]: s.64], the students can prefer different thinking styles according to the problem or situation [57], and the different information processing forms can develop in each individual whether the individual is aware of it or not [11].

The fundamental problem of this present study is to determine the effect of students' thinking styles on their attitudes toward PBL (ATPBL), attitudes toward web based learning (ATWBL) and academic achievement in online PBL. To that end, answers were sought to the following questions:

1. In online PBL, is there a significant difference between the mean ATPBL scores of students with different thinking styles?
   a. Is there a significant difference between their mean ATPBL scores in the pre and post application periods?
   b. Do the pre application attitude scores regarding PBL exhibit a significant difference from the post application attitude scores in terms of the students' thinking styles?
2. In online PBL, is there a significant difference between the academic achievement scores of students with different thinking styles?
   a. Is there a significant difference between academic achievement scores measured in the pre and post application periods?
   b. Do the pre application academic achievement scores significant difference with respect to the post application academic achievement scores in terms of students' thinking styles?
3. In online PBL, is there a significant difference between the mean ATWBL scores of students with different thinking styles?
   a. Is there a significant difference between their mean ATWBL scores in the pre and post application periods?
   b. Do the pre application attitude scores regarding WBL exhibit a significant difference from the post application attitude scores in terms of the students' thinking styles?

2 | METHOD

In this section, the research method, work group, and teaching materials used in the study are explained. Data collection tools and statistical analyses of collected data are also described.

2.1 | Research method

In cases including two or more groups and pre and post experiment measurements, the split-plot empirical method is utilized [13]. Therefore, the single-factor, pre-test post-test single group and semi empirical method was employed. The factor at this point is the variable of the study approach. Whereas the pre-test refers to the measurements taken before the application, the post-test refers the measurements at the end of the application. The effect of PBL on both groups was investigated in this study. The effect of this method, which was applied to all groups, on their ATP and on students' academic achievement was investigated.

2.2 | Work group

This study was conducted on 41 sophomore students receiving the Programming II Course and who were attending the Computer Teaching Department of a Faculty of Education at a public university during the spring semester of the 2016–2017 academic year in Turkey. The reason that the study was conducted on this student group was that the work group had taken Programming I during the fall semester of the sophomore year, and the fact that the programming course requires a high level of problem-solving and thinking skills.

2.3 | Planning and instruction of the course

In carrying out the online PBL activities, the Moodle Learning Management System was utilized. Before the application, students were informed about the usage of the Moodle Learning Management System. Moreover, after PBL was

explained, an example study was conducted. Seven individual problems were structured for students to find solutions during a period of 10 weeks in total. To form the problems, stories, tables, and prior course knowledge were utilized. Problems were presented in unique scenarios considering the learning targets. The fundamental targets of the 10-week program were determined to be the development of students' high-level thinking and problem-solving skills, the implementation of collaborative teaching, and the clarification of the effect of PBL in learning a programming language.

Students carried out these PBL activities, including the seven problems given, in a web environment, working collaboratively in groups. All information obtained in this process was shared, discussed, and assessed among members. Through this, the relevant solution was found. Finally, each group's solution to the problem was presented to other groups. The following steps were applied in planning the course:

a. First, the study approaches of students were determined. Then, the ATP and achievement pre-tests were applied.
b. Student groups were formed on a voluntary basis.
c. The problem scenarios were shared in the web environment.
d. Group members developed suggestions for solutions to the problems collaboratively.
e. Each of the groups was required to share their suggested solutions, to discuss them, and to decide on a single solution.
f. At the end of the 12-week process, the ATP and achievement tests were repeated as post-tests.

2.4 | Data collection tools

In data collection process, the Thinking Styles Scale, Attitude toward Problem Based Learning Scale (ATPBLS), Attitude toward Web Based Learning Scale (ATWBLS) and the Academic Achievement Test were utilized.

2.4.1 | Scale of thinking styles

Five likert type "Thinking Styles Scales" which is formed from 94 items and 14 factors and which is adopted into Turkish by [55], is used for determining the thinking styles of the students. Ten items were removed from the scale of [56] consisting of 104 items, as the result of the factor analysis and reliability analysis. In each article of the scale, a case is presented which shows the mental mindscape and forms of the person in any information and problem status and the individuals are requested to mention the frequency of this case on the scale [55]. The items are graded in the scale as follows; "Always (1)," "Frequently (2)," "Sometimes (3)," "Rarely (4)," and "Never (5)." Cronbach α reliability coefficient which is calculated for determining the internal consistency of the scale, change between 0.70 and 0.86 for all lower dimensions. At the same time, it is verified that the factor analysis and the scale form a structure of 13 factors after the change made by taking the item test and the item correlations as the basis.

In this study, the thinking styles that are described as Elaborator/Integrator, introvert/extrovert, and innovative/traditionalist in terms of the scope of the subject matter were investigated among 13 of thinking styles.

2.4.2 | Attitude toward web based learning scale

In order to measure the attitudes of students toward web-based instruction, a five-point Likert type "Web Based Instruction Attitude Scale" consisting of 26 items and two factors developed by [24] was used. As a result of the factor analysis and reliability analysis, 19 items were omitted from the scale of 45 items. In the factor analysis, it was determined that the scale, Kaiser Meyer Olkin (KMO) value of which is 0.833, consists of two sub-dimensions. The scale consists of sub-dimensions "Efficiency of Web Based Instruction" and "To resist web based instruction." The factor loadings for sub-dimensions of the scale are between 0.42 and 0.81. Internal consistency coefficient of the scale, the internal consistency coefficient (Cronbach Alpha) of which is calculated as 0.917 for all items thereof, was calculated as 0.813 for the sample group of this research.

2.4.3 | Attitude toward problem based learning scale

In the development of the Problem Based Instruction Attitude Scale, a scale was taken as a basis, which consists of 51 items for the superiority and limitations of the PBL applications and is prepared by [19]. This scale has been reduced to 44 items by omitting 7 items which are thought to be directly related to the Medical Faculty students. The items in the scale was classified as "1-Strongly disagree, 2-Disagree, 3-Neither agree or disagree, 4-Agree, 5-Strongly Agree." Items between 1 and 25 on the scale reflect positive opinions about PBL, whereas items between 26 and 44 reflect negative opinions. In order to determine the validity and reliability of the scale, a pilot study was conducted with 121 students who were not in the study group during the 2015–2016 Spring Semester. Before the pilot study, students were informed about PBL and a sample application was made. Factor analysis was performed for construct validity, whereas Cronbach Alfa Cronbach Alfa was used for reliability. As a result of the factor analysis, 44-item scale was reduced to 33 items. This 33-item scale includes 74.82% of the total variance. Internal consistency coefficients for the sub-dimensions of the scale range between 0.532 and 0.894. Internal consistency coefficient (Cronbach Alpha) for all scale was calculated as 0.824.

2.4.4 | Academic achievement test

An academic achievement test developed by the researcher was used to measure the academic achievement of students in the C# programming language. The draft academic achievement test comprises seven open-ended questions. To enhance the scope and validity of the test, the weight of subjects in distribution was taken into consideration. Moreover, test validity was maintained by consulting experts in programming teaching, measurement, and evaluation. While six questions were 15 points, one was 10 points, and total of 100 points. The validity of the test was assessed on the basis of pilot study during the spring semester of academic year 2015–2016 on 56 students not in the work group before the present study was carried out. Following the pilot study, two items were removed from the scale in the light of expert opinions.

2.5 | Analysis and interpretation of data

First, it was tested whether the factors employed were distributed normally or not, and whether or not they displayed homogenous distribution.

Fitness of data to the normal distribution is analyzed by the One Sample Kolmogorov–Smirnov Test. In the case that values on the row called the Assymp. Sig. (Significance) are greater than the threshold value of .05 in statistical significance assessment, it can be considered that the analyzed factors are normally distributed, whereas the reverse is the case if the value is less than .05 [36]. The significance values of factors used in the study are exhibited in Table 1.

From Table 1, it can be observed that since the significance values of all factors used in the study were greater than .05, these factors were normally distributed.

The significance values of factors that obtained homogenous test are exhibited in Table 2.

From Table 2, it can be observed that since the significance values of all factors were greater than .05, distribution of all factors was homogeny, which suggested that parametric tests could be used in the analysis.

The *t*-test is conducted in empirical studies in which there are two interrelated measurements or scores; in other words, it is used for cases in which repeated measurements of the same subjects are taken and the differences between these two measurements are investigated [13]. Therefore, the *t*-test was employed to determine whether there was a significant difference between pre- and post-application measurements of attitude and academic achievement scores.

In general, the analysis of covariance (ANCOVA) test is conducted to determine whether there is significant difference in methods between the pre- and post-test measurements of the experimental and control groups [13]. At this point, ANCOVA tests whether post-test scores corrected according to the pre-test scores cause significant difference between groups. Accordingly, single factor covariance analysis (ANCOVA) was employed in order to determine whether the post-test scores displayed a significant difference with respect to the attitude and achievement scores before the application in terms of the relevant thinking styles.

TABLE 1 Factors and normal distribution significance values

Factors	Significance
Attitude toward web based learning scale pre-test	0.373
Attitude toward web based learning scale post-test	0.469
Attitude toward problem based learning scale pre-test	0.729
Attitude toward problem based learning scale post-test	0.450
Academic achievement pre-test	0.527
Academic achievement post-test	0.693

TABLE 2 Factors and normal distribution significant values

Factors	Significance
Attitude toward web based learning scale pre-test	0.676
Attitude toward web based learning scale post-test	0.787
Attitude toward problem based learning scale pre-test	0.255
Attitude toward problem based learning scale post-test	0.957
Academic achievement pre-test	0.053
Academic achievement post-test	0.110

3 | FINDINGS

3.1 | Findings regarding ATPBL

Table 3 exhibits students' ATPBL pre- and post-test scores.

Whereas the mean ATPBL pre-test score of *elaborator* students was determined as $\bar{X} = 3.32$, the mean post-test score was determined as $\bar{X} = 3.74$. Whereas the mean ATPBL pre-test score of *integrator* students was determined as $\bar{X} = 3.21$, the mean post-test score was determined as $\bar{X} = 3.52$. Whereas

TABLE 3 Mean pre-test and post-test scores regarding ATPBL

	Pre-test			Post-test		
Group	*n*	$\bar{X}$	*s*	*n*	$\bar{X}$	*s*
Elaborator	29	3.32	0.36	29	3.74	0.31
Integrator	12	3.21	0.46	12	3.52	0.29
Introvert	24	3.30	0.34	24	3.63	0.31
Extrovert	17	3.26	0.46	17	3.74	0.31
Innovative	33	3.29	0.38	33	3.67	0.34
Traditionalist	8	3.27	0.46	8	3.68	0.22
Total	41	3.29	0.39	41	3.68	0.32

TABLE 4 *T*-test results on mean pre-test and post-test scores obtained from the ATPBLS

ATPBL	*n*	$\bar{X}$	*s*	sd	*t*	*p*
Pre-test	41	3.29	0.41	40	53.85	.00
Post-test	41	3.68	0.31			

the mean pre-test score of *introvert* students in the second sub-dimension was determined $\bar{X} = 3.30$, the mean post-test score was determined as $\bar{X} = 3.63$. Whereas the mean pre-test score of *extrovert* students was determined as $\bar{X} = 3.26$, the mean post-test score was determined as $\bar{X} = 3.74$. Whereas the mean pre-test score of *innovative* students in the third sub-dimension was determined $\bar{X} = 3.29$, the mean post-test score was determined as $\bar{X} = 3.67$. Whereas the mean pre-test score of *traditionalist* students was determined as $\bar{X} = 3.27$, the mean post-test score was determined as $\bar{X} = 3.68$. The overall mean ATPBL pre- and post-test score of students were determined as $\bar{X} = 3.29$ and $\bar{X} = 3.68$, respectively

To determine whether there was a significant difference between ATPBL pre- and post-test scores, the results of the *t*-test concerning observed differences in students' ATPBL scores are exhibited in Table 4.

A dependent sample *t*-test was conducted to compare ATPBL pre- and post-test results of the students (Table 4). According to *t*-test results, there is a significant difference between pre-test result ($\bar{X} = 3.29$) and post-test result ($\bar{X} = 3.68$); $t_{40} = 53.85$, $p = .00$. This finding suggests that the online PBL method might have a positive effect on students' attitude toward problem based learning in programming language teaching.

When the ATPBL pre-test scores were considered, single factor covariance analysis (ANCOVA) was employed to determine whether the post-test scores exhibited significant difference with respect to the thinking styles, and relevant results are summarized in Table 5.

According to the results of the single factor covariance analysis (ANCOVA), significant difference was determined between the ATPBL post-test scores corrected according to the ATPBL pre-test scores of *Elaborator* students with *Integrator* students, $F_{1-38} = 42.73$, $p < .005$. Similarly significant difference was determined between the ATPBL post-test scores corrected according to the ATPBL pre-test scores of *Introvert* students with *Extrovert* students, $F_{1-38} = 48.10$, $p < .005$. On the other hand no significant difference was determined between the ATPBL post-test scores corrected according to the ATPBL pre-test scores of *Innovative* students with *Traditionalist* students, $F_{1-38} = 41.77$, $p < .005$.

The corrected ATPBL score of *elaborator* students ($\bar{X} = 3.72$) were higher than the score of *integrator* students ($\bar{X} = 3.56$), the score of *extrovert* students ($\bar{X} = 3.76$) were higher than the score of *introvert* students ($\bar{X} = 3.62$). Corrected ATPBL the score of *innovative* students ($\bar{X} = 3.69$) were almost equal to the score of *traditional* student ($\bar{X} = 3.69$).

To determine the significance of this difference, effect size was investigated. Effect size indicates how much of the total variance in the variable is explained and is between 0.00 and 1.00. Eta square values of 0.20, 0.50, and 0.80 are evaluated as small, medium, and large effect size, respectively. It was determined that *Elaborator-integrator* and *introvert-extrovert* thinking styles had a high effect size on students' the ATPBL scores $(\eta^2 = 0.85; \eta^2 = -0.82)$, *innovative-traditional* thinking styles had a low effect size on the ATPBL scores $(\eta^2 = -0.079)$.

As a result, students' ATPBLs are related to their thinking styles. *Elaborator* students were more positive attitude than *integrator* students, *extrovert* students were more positive attitude than *innovative* students.

3.2 | Findings regarding academic achievement

Academic achievement pre- and post-test scores of students are exhibited in Table 6.

TABLE 5 ANCOVA results of corrected post-test scores according to the ATPBL pre-test scores with respect to thinking styles

Variance Re	Sum of squares	SD	Mean squares	*F*	*p*
AKPBL pre-test	1.933	1	1.933	42.727	.000
Elaborator-integrator	.221	1	.221	4.888	.033
Error	1.719	38	.045		
AKPBL pre-test	2.195	1	2.195	48.100	.000
Introvert-extrovert	.206	1	.206	4.524	.040
Error	1.734	38	.046		
AKPBL pre-test	2.131	1	2.131	41.74	.000
Innovative-traditionalist	.002	1	.002	.039	.844
Error	1.939	38	.051		
Total	559.087	41			

TABLE 6 Mean academic achievement pre-test post-test scores

	Pre-test			Post-test		
Group	***n***	$\bar{X}$	***s***	***n***	$\bar{X}$	***s***
Elaborator	29	46.34	11.39	29	65.31	10.11
Integrator	12	54.00	18.09	12	61.16	14.65
Introvert	24	47.83	14.80	24	63.50	13.26
Extrovert	17	49.64	12.88	17	64.94	9.03
Innovative	33	47.15	13.91	33	64.72	12.08
Traditionalist	8	54.50	12.99	8	61.50	9.54
Total	41	48.58	13.90	41	64.09	1.59

Whereas the mean academic achievement pre-test score of *elaborator* students was determined as $\bar{X} = 46.34$, their mean post-test score was determined as $\bar{X} = 65.31$. Whereas the mean academic achievement pre-test score of *integrator* students was determined as $\bar{X} = 54.00$, their mean post-test score was determined as $\bar{X} = 61.16$. Whereas the mean academic achievement pre-test score of *introvert* students in the second sub-dimension was determined as $\bar{X} = 47.83$, their mean post-test score was determined as $\bar{X} = 63.50$. Whereas the mean academic achievement pre-test score of *extrovert* students was determined as $\bar{X} = 49.64$, their mean post-test score was determined as $\bar{X} = 64.94$. Whereas the mean academic achievement pre-test score of *innovative* students in the third sub-dimension was determined as $\bar{X} = 47.15$, their mean post-test score was determined as $\bar{X} = 64.72$. Whereas the mean academic achievement pre-test score of *traditionalist* students was determined as $\bar{X} = 54.50$, their mean post-test score was determined as $\bar{X} = 61.50$. In general, the mean academic achievement pre- and post-test score of all the students were determined as $\bar{X} = 48.58$ and $\bar{X} = 64.09$.

Regarding the significance of the difference observed in the academic achievement scores, the results of the *t*-test conducted to determine whether there was significant difference between academic achievement pre- and post-test scores are summarized in Table 7.

According to Table 7, the mean Academic achievement pre- and post-test scores of students were determined as $\bar{X} = 48.58$ and $\bar{X} = 64.09$, respectively. According to the t-test results, a significant increase was observed with the academic achievement scores of students in the post application period of the online PBL, $t_{40} = 22.38$, $p = .00$. This finding suggests that online PBL is positively related to students' academic achievement scores in programming language teaching.

When considering the academic achievement pre-test scores, single factor covariance (ANCOVA) analysis was conducted to determine whether the post-test scores exhibited significant difference with respect to the thinking styles, and the relevant results are exhibited in Table 8.

According to the results of single factor covariance analysis (ANCOVA), significant difference was determined between academic achievement post-test scores corrected according to the pre-test academic achievement scores of *elaborator* with *integrator* students, $F_{1-38} = 36.302$, $p < .005$. Similarly significant difference was determined between academic achievement post-test scores corrected according to the pre-test academic achievement scores of *innovative* with *traditionalist* students, $F_{1-38} = 30.636$, $p < .005$. On the other hand, no significant difference was determined between academic achievement post-test scores corrected according to the pre-test academic achievement scores of *introvert* with *extrovert* students, $F_{1-38} = 24.182$, $p < .005$.

The corrected the score of *elaborator* students ($\bar{X} = 66.64$) were higher than score of *integrator* students ($\overline{X} = 57.94$), score of *innovative* student ($\bar{X} = 65.54$) were higher than score of *traditionalist* students ($\bar{X} = 58.15$). The corrected the score of *introvert* students ($\bar{X} = 63.89$) were almost equal to the score of *extrovert* student ($\bar{X} = 64.38$.)

To determine the significance of this difference, effect size was investigated, and it was determined that *Elaborator-integrator* with *innovative-traditional* thinking styles had a high effect size on students' the academic achievement scores $\left(\eta^2 = 0.90; \eta^2 = 0.82\right)$, *introvert-extrovert* thinking styles had a low effect size on the scores $\left(\eta^2 = 0.12\right)$.

As a result, students' the academic achievement scores are related to their thinking styles. *Elaborator* students were more successful than *integrator* students. Similarly, *innovative* students were more successful than *traditionalist* students.

3.3 | Findings regarding ATWBL

Table 9 exhibits students' ATWBL pre- and post-test scores.

Whereas the mean ATWBL pre-test score of *elaborator* students was determined as $\bar{X} = 3.48$, the mean post-test score was determined as $\bar{X} = 3.93$. Whereas the mean ATWBL pre-test score of *integrator* students was determined as $\bar{X} = 3.36$, the mean post-test score was determined as

TABLE 7 T-test results of mean academic achievement pre-test and post-test scores

Academic achievement	***n***	$\bar{X}$	***s***	**sd**	***t***	***p***
Pre-test	41	48.58	13.90	40	22.38	.00
Post-test	41	64.09	11.59			

TABLE 8 ANCOVA results of corrected post-test scores according to the academic achievement pre-test scores with respect to thinking styles

Variance resource	Sum of squares	SD	Mean squares	*F*	*p*
Academic achievement pre-test	2555.186	1	2555.186	36.302	.000
Elaborator-integrator	600.243	1	600.243	8.528	.006
Error	2674.688	38	70.387		
Academic achievement pre-test	2082.466	1	2082.466	24.182	.000
Introvert-extrovert	2.455	1	2.455	.029	.867
Error	3272.475	38	86.118		
Academic achievement pre-test	2369.492	1	2369.492	30.636	.000
Innovative-traditionalist	335.877	1	335.877	4.343	.044
Error	2939.053	38	77.344		
Total	173824.000	41			

$\bar{X} = 3.55$. Whereas the mean pre-test score of *introvert* students in the second sub-dimension was determined $\bar{X} = 3.42$, the mean post-test score was determined as $\bar{X} = 3.82$. Whereas the mean pre-test score of *extrovert* students was determined as $\bar{X} = 3.49$, the mean post-test score was determined as $\bar{X} = 3.82$. Whereas the mean pre-test score of *innovative* students in the third sub-dimension was determined $\bar{X} = 3.42$, the mean post-test score was determined as $\bar{X} = 3.88$. Whereas the mean pre-test score of *traditionalist* students was determined as $\bar{X} = 3.57$, the mean post-test score was determined as $\bar{X} = 3.57$. The overall mean ATWBL pre- and post-test score of students were determined as $\bar{X} = 3.45$ and $\bar{X} = 3.82$, respectively.

To determine whether there was a significant difference between ATWBL pre- and post-test scores, the results of the *t*-test concerning observed differences in students' ATWBL scores are exhibited in Table 10.

A dependent sample *t*-test was conducted to compare ATWBL pre- and post-test results of the students (Table 10). According to *t*-test results, there is a significant difference between pre-test result ($\bar{X} = 3.45$) and post-test result ($\bar{X} = 3.82$); $t_{40} = 37.66$, $p = .00$. This finding suggests that the online PBL method might have a positive effect on students' attitude toward web based learning in programming language teaching.

TABLE 9 Mean pre-test and post-test scores regarding ATWBL

	Pre-test			Post-test		
Group	***n***	$\bar{X}$	**s**	***n***	$\bar{X}$	**s**
Elaborator	29	3.48	0.63	29	3.93	0.56
Integrator	12	3.36	0.48	12	3.55	0.46
Introvert	24	3.42	0.54	24	3.82	0.58
Extrovert	17	3.49	0.66	17	3.82	0.53
Innovative	33	3.42	0.60	33	3.88	0.56
Traditionalist	8	3.57	0.54	8	3.57	0.45
Total	41	3.45	0.59	41	3.82	0.56

When the ATWBL pre-test scores were considered, single factor covariance analysis (ANCOVA) was employed to determine whether the post-test scores exhibited significant difference with respect to the thinking styles, and relevant results are summarized in Table 11.

According to the results of the single factor covariance analysis (ANCOVA), significant difference was determined between the ATWBL post-test scores corrected according to the ATWBL pre-test scores of *Elaborator* students with *Integrator* students, $F_{1-38} = 21.22$, $p < .005$. Similarly significant difference was determined between the ATPBL post-test scores corrected according to the ATWBL pre-test scores of *Innovative* students with *Traditionalist* students, $F_{1-38} = 26.20$, $p < .005$. On the other hand no significant difference was determined between the ATPBL post-test scores corrected according to the ATPBL pre-test scores of *Introvert* students with *Extrovert* students, $F_{1-38} = 20.93$, $p > .005$.

The corrected ATWBL score of *elaborator* students ($\bar{X} = 3.92$) were higher than the score of *integrator* students ($\bar{X} = 3.60$), the score of *innovative* student ($\bar{X} = 3.90$) were higher than the score of *traditionalist* students ($\bar{X} = 3.50$). Corrected ATWBL the score of *introvert* students ($\bar{X} = 3.84$) were almost equal to the score of *extrovert* student ($\bar{X} = 3.81$).

To determine the significance of this difference, effect size was investigated, and it was determined that *Elaborator-integrator* and *innovative-traditionalist* thinking styles had a high effect size on students' the ATWBL scores $\left(\eta^2 = 0.26; \eta^2 = 0.78\right)$.

TABLE 10 *T*-test result on mean pre- and post-test obtained from the ATWBLS

ATWBL	*n*	$\bar{X}$	*s*	sd	*t*	*p*
Pre-test	41	3.45	0.58	40	37.66	.000
Post-test	41	3.82	0.56			

TABLE 11 ANCOVA results of corrected post-test scores according to the ATPBL pre-test scores with respect to thinking styles

Variance resource	Sum of squares	SD	Mean squares	*F*	*p*
AKWBL pre-test	3.992	1	3.992	21.223	.000
Elaborator-integrator	.846	1	.846	4.498	.041
Error	7.147	38	.188		
AKWBL pre-test	4.396	1	4.396	20.929	.000
Introvert-extrovert	.010	1	.010	.048	.827
Error	7.982	38	.210		
AKWBL pre-test	4.804	1	4.804	26.196	.000
Innovative-traditionalist	1.024	1	1.024	5.584	.023
Error	6.969	38	.183		
Total	612.120	41			

As a result, students' ATWBLs are related to their thinking styles. *Elaborator* students were more positive attitude than *integrator* students. Similarly, *innovative* students were more positive attitude than *traditionalist* students.

4 | DISCUSSION AND CONCLUSION

It was observed that applying online PBL had a positive effect on students' ATPBL. This finding suggests that the PBL has positive effect on students' attitudes toward the programming course, a course in which a relatively negative attitude and low motivation levels are usually observed.

This result is similar to the literature. Pereira et al. [46] claimed that the logical thinking capabilities of programming students could be enhanced through PBL. These researchers employed various programming tools such as the Turing Machine and Cellular Robot programming in their study. One of the objectives of PBL is to increase productivity by means of collaborative teaching. Serrano-Cámara et al. [52] investigated student motivation in an environment in which programming teaching was supported by collaborative teaching tools. Their results showed that the cooperative teaching method had a positive effect on motivation. In similar studies in which the PBL method was applied, positive changes were observed in student attitudes [2,40,38]. Gholami et al. [30] was conducted to compare the effects of PBL and the traditional lecture method on critical thinking skills and metacognitive awareness in nursing students in a critical care nursing course. It was determined a statistically significant effect for the PBL method on the development of critical thinking skills and metacognitive awareness in nursing students.

In addition to this, with regard to the pre-test scores concerning students' ATPBL, it was determined that the corrected post-test scores did exhibit significant variance according to their thinking styles. Whereas the corrected ATPBL score of *elaborator* students were higher than *integrator* students, *introvert* students were higher than *extrovert* students. In other words, *elaborator* and *extrovert* students have a more positive view of problem-based learning than other learners. This result; suggesting that the preferred thinking style causes different attitudes toward problem-based learning to be exhibited.

In the relevant literature, no study focusing on the effect of the online PBL on ATPBL in terms of thinking styles was found. However, our findings can be supported by results reported in studies in which the effects of different personal characteristics on attitude and achievement were investigated. Tekedere and Mahiroğlu [59] revealed that a focus on supervision produces a significant difference on students' attitudes toward online learning. Cheng and Chau [16] reported a significant correlation between learning approaches and online participation. On the other hand Alper and Deryakulu [3] studied the effect of the level of cognitive flexibility in student-directed PBL in a web environment on students' achievement, attitudes, and the durability of learning. The researchers reported that the use of PBL did not have an effect on the cognitive flexibility level.

The second question in this study was about the effect of the use of the online PBL on academic achievement. As a result use of the online PBL, the academic achievement levels of all students increased. This result shows that the online PBL have a positive effect on students' academic achievement scores in programming language teaching. Similarly, Alper and Deryakulu [3] reported the online PBL have a positive effect on the students' scores. Pereira et al. [46] have investigated a contribution to the teaching of object-oriented programming languages through a game-oriented approach based on the interaction with tangible user interfaces (TUIs). It has been observed that the students from the experimental group achieved an overall better mark.

In their study investigating the effect of PBL on student achievement in a math course, Uygun and Tertemiz [62] reported that the students from the experimental group using PBL were more successful. Verdú et al. [63] have developed

an e-learning platform that automatically evaluates the solutions of problems in a study they conducted to develop new learning strategies that would provide students with easier and more attractive programming training and motivation. It was found that academic achievements of the students are contributed as a result of the application. In a study of Sarıtepeci and Çakır [50] that investigated the effect of blended learning on academic achievement and attendance to lesson of students, they found that blended learning was more effective than face-to-face learning in terms of both academic achievement attendances to lesson. Topalli and Cagiltay [61] found that the performance of students on the graduation projects improved significantly by improving the course curriculum slightly through real-life game development projects in the Scratch environment. Similarly, Etiubon and Ugwu [28] also found that students who has been taught with problem based-learning approach had higher scores than students who has been taught with expository approach.

Ersoy et al. [25] concluded that robot programming techniques and programming education have a positive effect on student achievement. Similarly, other studies also concluded that PBL has a positive effect on academic achievement [2,15,54], supporting the findings of our study.

On the other hand, Students' post-test scores modified according to their pre-test scores according to their academic achievement exhibited significant differences in terms of the thinking styles used. Whereas the academic achievement scores of the *elaborator* students were more achievement than the *integrator* students, the *innovative* students were more achievement than the *traditionalist* students. This finding suggests that the thinking styles produces a significant difference in students' academic achievement scores. In the relevant literature, no study focusing on the effect of the PBL on academic achievement in terms of thinking styles was found. However, our findings can be supported by results reported in studies in which the effects of different personal characteristics on attitude and achievement were investigated. Shaw [53] reported that there was significant correlation between students' study approaches and their academic achievement scores in online programming language training. Lee [42] reported that the academic achievement of students with the *deep* approach were found to be higher than other students. Hwang et al. [34] designed an online collaborative teaching environment to facilitate programming education. As a result of applying this, researchers found that learning styles have a positive effect on learning achievement.

The third question in this study was about the effect of the use of PBL on students' ATWBL. It was observed that applying online PBL had a positive effect on students' ATWBL. These findings suggest that the online PBL has positive effect on students' ATWBL. In addition to this, with regard to the pre-test scores concerning students' ATWBL, it was determined that the corrected post-test scores did exhibit significant variance according to their thinking styles. Whereas the corrected ATPBL score of *elaborator* students were higher than *integrator* students, *innovative* students were higher than *traditionalist* students. In other words, *elaborator* and *innovative* students have a more positive view of web-based learning than other learners. This result; suggesting that the preferred thinking style causes different attitudes toward web-based learning to be exhibited.

This result is similar to the literature. Shaw [53] found that programming language instruction supported by online forms increased student satisfaction and participation but no significant was determined between students' study approaches and their satisfaction. Tekedere and Mahiroğlu [59] revealed that a focus on supervision produces a significant difference on students' attitudes toward online learning.

As a result, programming teaching is considered to be one of the hardest subjects for students to handle because programming teaching requires high-level problem solving and thinking skills. One of the methods that could be chosen in order to develop these high-level skills is the PBL method. For this reason, the online PBL method was used in the programming course in this study. The study concluded that online PBL has a positive effect on students' ATPBL, ATWBL and academic achievements in programming teaching. Attitude is an essential factor in achievement and productivity. Attitude is an important element in achievement and productivity. For this reason, it is necessary to make such applications and discuss their results for more effective programming teaching.

It was determined that the thinking styles which are proposed by Sternberg [57] in connection with the theory of mental memory lead to significant differences in favour of *Elaborative* and *Extrovert* students for the attitude toward PBL, whereas they lead significant differences in favour of *Elaborative* and *Innovative* students for the attitude toward WBL. Therefore, the thinking style of the students should be taken into consideration while designing the teaching environment and during the application.

Thinking styles of students have resulted in significant differences in favor of *Elaborative* and *Innovative* students for academic achievement. In addition, it has been observed that during the application, the *Integrator* and *Traditionalist* students have difficulties for understanding the problem sentences and for providing solutions for the problem scenarios.

It has been observed that students have achieved different levels of success despite they make the same effort during the application. The reason for this may be that the students initially have different skills and attitudes. Therefore, it is suggested that the personal characteristics of the students should be taken into account in the instructional environment design and be guided correctly during the application.

4.1 | Limitations

A study to be carried out with the actual experimental pattern of experimental and control groups can be made. Furthermore, the experience of students with prior knowledge of problem-based learning can lead to more consistent results.

4.2 | Suggestions

Since the present study is precursor research, which takes the effect of thinking styles into consideration in the use of online PBL, it is expected to make a contribution to the literature on PBL. Furthermore, the most suitable teaching environments for programming teaching can be determined by similar studies to be done in learning environments designed considering the individual differences of the students. The impact of the PBL on the strategies which students use to solve problems can be investigated. In addition, group assignments can be made according to the readiness of the students such as cognitive flexibility levels and preliminary knowledge levels. Moreover, a similar application can be repeated in the coding courses at secondary level.

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