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The effect of virtual learning environments designed according to problem-based learning approach to students' success, problem-solving skills, and motivations

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Abstract

The goal of this research is to present the effects of virtual learning environments, specifically designed according to the problem-based learning approach (PBL) for 7th-grade students' science lessons. The effects of these specific environments on students' academic success, problem-solving skills and motivations were carefully analyzed and interpreted. In this context, mixed-method, combining qualitative and quantitative methods, was adopted. The pre-test-post-test control group designs were used in the quantitative dimension of the study and the focus group interview was conducted with the experimental group students to support the quantitative findings. The study group of the research involved 68 students in 7th grade in a secondary school. At the end of the research, on the basis of the quantitative data analysis it can be said that: According to the last-tests of the experimental and control groups, the virtual learning environment designed on the basis of the problem-based learning approach was more efficient on increasing the academic success and problem-solving skills of the experimental group students when compared to the control group students. However, findings of the motivation survey indicate that motivations of the experimental and control groups didn't significantly differentiate. According to the quantitative results of the research, experimental group students delivered positive opinions especially about making

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lessons more fun and relating to real-life, which are the parts of the virtual learning environment designed according to the problem-based learning approach. It was observed that, in terms of the activities, students had positive opinions mostly about giving the chance to discuss opinions and make interpretations. In addition to this, it was seen that the students believed that their problem-solving skills had developed thanks to the activities. Regarding the topic of conducting group studies while using virtual learning methods, students stated that they had positive opinions as these studies gave them the opportunity to exchange ideas. However, they were disturbed by the fact that there were too many irrelevant interpretations during the process.

Keywords Problem-based learning · Virtual learning · Academic success · Problem-solving skill · Motivation

1 Introduction

Education, enabling human beings' and societies' growth in the global world with decreasing boundaries, is a long-term investment and the biggest necessity of the time. Acquiring some basic skills, accessing information, establishing healthy social relations and reaching career goals are mostly related to education. Individuals can only cope with the changes and developments, have a wider perspective about the world and generate ideas in today's world, with dizzying developments in science and technology, only through qualified education. Instead of simply memorizing information, prioritized in rote learning, individuals are now expected to use the knowledge they obtain in the right place at the right time. This state can be associated with significant changes in the expected qualifications, increasing resources of information and acceleration in reaching these resources (Trilling and Fadel 2009). Accordingly, it is now necessary to support the complex skills of individuals such as using the mind in a collective manner, making knowledge more flexible, having problem-solving skills and establishing efficient social communication (Arslan 2007; Balay 2004; Celen et al. 2011; Kaya 2013). Turkish National Ministry of Education (MEB) (2018) defines the individual as the person who produces information and uses what he/she learns in daily life, who can think critically, who is innovative, determined, entrepreneur, who has healthy social communication and can empathize. Based on this definition, the ultimate goal of students in daily life should be generating a way to solve an encountered problem, taking all of the necessary steps to reach a solution and personally organizing this process. At this point, the problem-based learning approach (PBL) becomes prominent. The goals of this learning approach, which prioritizes involving the student in the learning process actively (Bridges 1992), are enabling students to develop their problem-solving skills by gaining the skills of questioning, researching, discussing and assessing (Silver 1994; Herron and Major 2004). In this study, the problem-based learning approach is used in the virtual learning environment, different from the traditional classroom environment. Virtual learning environments can be expressed in different ways such as web-based learning, internet-based learning, online learning and e-learning. Although these concepts converge on many points, they also have important differences (Phungsuk et al. 2017). It can be said that the concept of virtual learning environments has a wider meaning that includes other terms (Ngai et al. 2007; Oxford University Press 2015).

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Virtual learning environments have characteristics that can meet some requirements of PBL. Some of these requirements are;

- Communication and cooperation among students are significant in the PBL approach (Duch et al. 2001).
- Teacher, as a guide, makes directions necessary for enabling students to take personal learning responsibilities (Herron and Major 2004). In this frame, the simultaneous guiding of teachers and interaction of students with their peers can be beneficial (Gould et al. 2015).
- Fast and easy access to necessary information resources is significant for the student to solve the encountered problem (Chin and Chia 2004).
- Some students can be shy to engage in group activities, they may not be able to express themselves in the way they want and such situations may not be noted in groups (Hussain et al. 2007; Johnson and Finucane 2000).

The advantages of virtual learning environments can create suitable environments for conducting PBL approaches in similar situations on the basis of this learning approach. In this context, virtual learning environments, in which technology use has been increasing, are analyzed in the frame of the PBL approach. One of the most significant problems in the use of technology in education is the wish to integrate technologies in lessons without taking a specific learning approach or model as the grounding (Mishra and Koehler 2006). This study, formed on the basis of this frame, is regarded as significant as it evaluates the PBL approach in a different dimension and sets an example for the use of a virtual learning environment in real classroom environments.

On the other hand, this study was conducted specifically in a Science lesson. According to Soylu (2004), Science is the activities of inquiring the universe, discovering, finding and expressing its hidden orderliness. In fact, science education is learning real life (Aydogdu 2012) as it structurally has the qualifications of enabling students to understand and get used to their environment and question every kind of natural phenomena that they encounter in daily life (Gul 2006). According to Ozsevgec (2006), as science lesson is made of a variety of abstract concepts, it is more complicated than the other lessons and requires cognitive skills. At this point, the PBL approach, which contributes to developing problem-solving and high-level thinking skills of students, comes into prominence. As students are required to take an active role in the learning processes on the basis of this approach, it is believed that the use of PBL approach is beneficial (Sendag and Odabasi 2009; Senocak and Taskesenligil 2005; Jones-Wilson 2005). The student directly participates in the learning process in this approach and acquires learning by constructing the new information under the light of his/her previous knowledge (Aydogdu 2012). On the other hand, it is observed that the use of this approach in Science lessons, which prioritize learning through experience, has positive impact on significant factors such as academic success, attitude, motivation, problem-solving skill and motivation (Aka 2012; Aydogdu 2012; Celik 2013; Coban 2014; Figueira and Rocha 2014; Kelly and Finlayson 2009; Kılıc and Moralar 2015; Korucu 2007; Temel et al. 2015; Wong and Day 2009), this is why science education should be based on learning through practice, experience and discovery. Revealing the sense of wonder in students will reveal their wish to discover. It is thought that the virtual learning environments supported by the PBL approach will push students towards learning by revealing their sense of wonder. In brief, PBL, a student-centered approach can be regarded as a proper approach for reaching the goals of Science lessons as it develops efficient problem-solving skills, transfer of knowledge in new problematic states and supports cooperative skills. In addition to these, it is believed that the findings of the study will contribute to the training programs to be revised in terms of educational methods and instruction fields. On the other hand, as there is no theoretical frame on the design and implementation of virtual learning environments on the basis of the PBL approach (Budakoglu et al. 2018) research results are regarded as significant; the results are believed to make some contributions to the literature in this respect.

The goal of this study is to determine and present the effects of virtual learning environments designed according to the problem-based learning approach in 7th-grade students' Science lessons, on their academic success, problem-solving skills, and motivations. The sub-problems determined in the frame of this purpose are presented below:

- Is there a significant difference between the experimental and control groups in terms of their post-test academic success, problem-solving skills and motivations about the lesson?
- Is there a significant difference in the pre-test and post-test of the control group in terms of their academic success, problem-solving skills and motivations about the lesson?
- Is there a significant difference in the pre-test and post-test of the experimental group in terms of their academic success, problem-solving skills and motivations about the lesson?
- What are the opinions of the experimental group students about the virtual learning environments that they experienced?

2 Method

The mixed-method, combining quantitative and qualitative methods, was used in the research. The basic assumption of the mixed method is to combine quantitative and qualitative data; the method is used for the purposes of minimizing the limitations resulting from the use of a single research method, obtaining extensive data and supporting the collected data (Creswell 2008). The embedded mixed-method, one of the mixed-method research types, was preferred in this study. Data are either simultaneously or alternately collected in the embedded mixed method researches and one data type has the supporting role (Creswell 2008). Firstly quantitative data had been collected in this research; following this process, qualitative data were collected to support the quantitative data and provide a new viewpoint.

Pre-test post-test experimental design with the control group was used in the quantitative dimension of the research. The symbolic representation of the preferred experimental design is presented below in Table 1.

The experimental design in Table 1 is made of an experimental and a control group. Problem-solving skill assessment tests (PSSAT1) conducted before the experimental design as the data collection instrument, were used as the pre-test for both groups. On the other hand, the academic success test (AST), problem-solving skill assessment test (PSSAT), and motivation survey (MS) were used both as pre-test and post-test.

The qualitative research methods were used in the qualitative dimension of the study. A focus group interview was held with the students to support the quantitative data.

2.1 Study group

The study group of the research involved 68 students in 7th grade in a secondary school in a city with a medium socio-economic level during the 2018–2019 academic semesters. Some of the criteria taken into consideration in determining the school for the research were: Support of school management, support of Science teachers with whom the research was conducted, having two or more 7th-grade classes, having computer laboratories with a sufficient number of computers.

The study group of the research was chosen with a purposeful sampling method which is one of the non-random sampling methods. Students in two of the six different 7th grades in the school were included in the research with this sampling method. The school administration was interviewed for the selection of these two classes. The chosen two classes were randomly determined as control and experimental groups. The distribution of students in the study group in terms of gender and groups is presented in Table 2.

In order to control whether or not these groups were equal, Science lesson written test results were analyzed and the academic success test prepared by the researcher was conducted as the pre-test. Independent groups t-test analysis was carried out to determine if the difference between the groups' scores on the academic success test was meaningful. In order to determine if the data were normally distributed, the values were analyzed with the Shapiro-Wilk test before the independent groups t-test. At the end of

Table 1 Experimental Design of the Study

Groups	Sampling	The lesson	Pre-test	Experimental Process	Post-test
Experimental	Random Sampling	7th Grade Science lesson	PSSAT1 PSSAT AST MS	Virtual Teaching Practices on the basis of the PBL approach	PSSAT AST MS
Control	Random Sampling	7th Grade Science lesson	PSSAT 1 PSSAT AST MS	In-class Teaching Practices on the basis of the PBL approach	PSSAT AST MS

Table 2 Distribution of Study Group Students in terms of Gender and Groups

Group	The Number of Students	Gender			
		Female		Male	
Control Group		*f*	%	*f*	%
Crazy Buddies	9	5	56	4	44
Solution Team	8	4	50	4	50
The Scholars	8	4	50	4	50
The Invincible	8	4	50	4	50
Total	33	17	52	16	48
Experimental Group					
Science Bugs	9	5	56	4	44
Hardworking Bees	9	4	44	5	56
Solvers	9	4	44	5	56
Brain-Boxes	8	4	50	4	50
Total	35	17	49	18	51

the test, it was determined that $p > .05$. The results obtained from the t-test are presented below in Table 3.

As can be seen in Table 3, there is no meaningful difference between the groups' pre-test scores ($p < .05$). According to these results, it can be said that the groups had similar characteristics and they were equal.

The experimental group on whom the problem-based learning approach was conducted in a virtual environment involved a total of thirty-five individuals. The students in the group were divided into four groups to conduct the group study, as required by the PBL. Moreno et al. (2012) stated that the ideal situation to be considered when forming a group in order for students to achieve high-level learning is to maximize the individual differences of students within the group. In similar studies (Johnson et al. 1994; Scheurell 2010) it was argued that the most influential groups should be a mix of students in terms of abilities, gender and ethnicity. Science lesson academic success of students and observations of science teachers were taken into consideration while creating the groups; the purpose at this stage was to ensure that the students in the same group had different academic levels with different skills and abilities. Three of the groups involved nine individuals while one group involved eight individuals. On the other hand, the group members were required to find a name for their group. "Science Bugs, Hardworking Bees, Solvers, and Brain-Boxes" were the names of the groups.

Table 3 Independent Groups T-Test Results of the Experimental and Control Groups' Pre-test Success Scores

Groups	N	$\overline{X}$	SS	sd	t	p
Control	33	27,83	11,13	66	−985	.328
Experimental	35	26,21	10,66			

The control group on whom the problem-based learning approach was conducted in a classroom environment involved a total of thirty-three individuals. The students were divided into four groups. Three of the groups involved eight individuals while one group involved nine individuals. Names of the four control groups were "Crazy Buddies, Solution Team, the Scholars and the Invincible". Students were directed towards finding solutions to problem-cases presented to them; they were required to primarily work individually and then work in their small group. Experimental group students were encoded as "ES1" while control group students were encoded as "CS1" during the analyses.

Qualitative dimension of the research: In order to find the answer to the fourth sub-problem, two students were selected from each experimental group; a total of 8 students volunteered.

2.2 Data collection tools

1. Problem-Solving Skill Assessment Tests Conducted Before the Experimental Process

Before starting the experimental process in the research, the researcher made careful literature review and wrote three different stories (Danger in the Space, Curiosity of Muhiddin, Camping Adventure of Asli and her Family) by taking the age range of the 7th-grade students into consideration. The purpose of this process was to determine if students had problem-solving skills. The topics that had been covered in the scope of the Science Curriculum until the experimental process in the 2018 academic year in Turkey were taken into consideration while writing these stories. Interrater reliability analysis was conducted to test the reliability of these tests. In this scope, the intraclass correlation coefficient-R1 was calculated for each question. On the other hand, stories were evaluated by the "Problem-Solving Assessment Test Graduate Scoring Key" specifically developed by the researcher. The average coefficient of concordance among the test scores of sixty-eight students that answered the question was analyzed with three different scorers. The coefficient of concordance was calculated by determining the consistency among the scores given by more than one rater. This coefficient is defined as the degree of consistency and consistency between two or more raters (Cohen et al. 1996). The highest score of 100 can be obtained from this test. Accordingly, the existing problem solving skill scores of the experimental group students were calculated as 73, and the control group students as 71.

2. Academic success test

The researcher developed a multiple-choice success test. The purpose of the test was to assess the academic success level of students in the scope of the learning unit titled "Force and Energy"in the 7th-grade level. The unit was included in the Science Curriculum designed for Primary and Secondary School 3rd, 4th, 5th, 6th, 7th and 8th grades.

Eight different learning outcomes were taken into consideration while preparing the test. Firstly, a question pool involving two hundred questions about the learning outcomes was prepared. Then, some of these questions were eliminated on the basis of the domain experts' opinions and the number of questions was decreased to one hundred and twenty-six questions. Questions with similar characteristics were eliminated again in line with the domain experts' opinions; criteria of writing articles were also taken into consideration while eliminating the questions. The principles to be considered while developing an achievement test as item writing principles were taken into account. These are clarity and comprehensibility of items, measuring a single behaviour for each item, compatibility of options with each other, avoiding negative statements as much as possible in the root of the item etc. (Haladyna 1997; Ozcelik 2010)

A form including a total of forty questions was prepared; every five questions in the form were specifically designed for covering one outcome in the unit. The distribution of test questions according to the unit learning outcomes is presented in Table 4.

The test formed for the pilot scheme was conducted throughout one lesson hour on a total of 200 students in different schools. Item analyses were carried out at the end of the pilot scheme and numeric data about the items for every learning outcome was obtained. At the end of the analyses, difficulty (p) and distinctiveness (r) indexes of the items were calculated. Items number 1, 9, and 20 were removed from the test as their distinctiveness indexes were below 0.19. The item difficulty indexes of the items in a test should be between 0.20 and 0.80; the item difficulty index average in the test in total is expected to be around0.50 (Buyukozturk 2011). Item difficulty average of the test is $p = 0.62$ and the distinctiveness mean is $r_{=}$ 0.45. The reliability coefficient of the academic success test made of forty items was calculated a (KR-20) 0.85. After removing the three items, the test was finalized with thirty-seven items. The difficulty average of the final version was $p = 0.61$, distinctiveness average was $r_{=}$ 0.46 and the reliability coefficient (KR-20) was0.92. The maximum possible test score was determined to be 100.

Table 4 Distribution of Test Questions about the Unit "Force and Energy" According to the Learning Outcomes

Topics of the Unit Force and Energy	Student Learning Outcomes about the Unit of Force and Energy	Question Number
1. Mass and Weight Relationship	1.1. He/she names gravitational forces that affect the mass as weight.	1, 5, 7, 9, 13
	1.2. He/she compares the concepts of mass and weight	2, 4, 10, 12, 29
	1.3. He/she explains gravity as gravitational force on the basis of celestial bodies.	3, 6, 8, 11, 26
2. Force, Activity and Energy Relationship	2.1. He/she explains that physical activity is associated with the applied force and distance.	14, 15, 16, 27, 31
	2.2. He/she associates energy with the concept of activity and classifies it as kinetic and potential energy.	17, 24, 25, 28, 32
3. Energy Transformations	3.1. On the basis of the transformation of kinetic and potential energy to one another, he/she draws the conclusion that energy is conserved.	18, 19, 23, 35, 38
	3.2. He/she explains the effect of friction force on kinetic energy through examples.	20, 21, 22, 30, 34
	3.3. He/she designs a vehicle for decreasing the air or water resistance.	33,36, 37, 39,40

3. Problem-solving skill assessment test

The problem-solving process is a seemingly complicated process with some specific steps. Brand-Gruwel et al. (2005) separated the problem-solving process into five main groups: "Defining the problem, researching data, selecting data, processing data and presenting data". On the other hand, Tambychik and Meerah (2010) defined the problem-solving process on the basis of three main phases: "Understanding the problem, determining the solution and confirming the answer by solving the problem". Problem-solving skills and processes have been defined by a variety of researchers in the literature. Problem-solving process steps determined as a result of the literature review are presented in the table below (Table 5).

In order to assess the students' problem-solving skills, the "Problem-Solving Skill Assessment Test" was developed by the researcher by taking these determined problem-solving steps into consideration. Questions in the test were equally distributed to each problem-solving process step. The prepared test was carefully analyzed by the Education Programs and Teaching Domain lecturers (1), Science Education Domain lecturers (2), and Science Teachers (3); necessary edits were completed in line with the suggestions of these professionals. The validity of the test was attempted to be ensured by taking the opinions of the experts. Scenarios are of big importance in the PBL approach as a learning process is shaped in line with the scenarios. After analyzing the expert opinions, the test was formed in a way that it included 8 scenarios and 20 classical questions. Topics in the unit were taken into consideration in the process of preparing the test for content validity. On the basis of this, four questions from the "Mass and Weight Relationship" topic, ten questions from the "Force, Activity and Energy Relationship" topic and six questions from the "Energy Transformations" topic were written.

Interrater reliability analysis was conducted in order to test the reliability of the problem-solving skill assessment test; for this purpose, intraclass correlation coefficient-R1 was calculated for each question. Results of 50 students answered the tests of three different raters were analyzed and the average coefficient of concordance between the scores on the basis of the item and in total were determined. At the end of the process, it was determined that the scoring reliability of the total test was .851. The

Table 5 Problem-Solving Process Steps

Step No	Problem-Solving Step	Source
1.	Sensing the problem (Perceiving, defining the problem)	Baytekin 2001; Brand-Gruwel et al. 2005; Tambychik and Meerah 2010
2.	Determining the cause of the problem	Bilen 2006; Brand-Gruwel et al. 2005; Pretz et al. 2003
3.	Finding solutions to the problem (Developing hypothesis)	Baytekin 2001; Brand-Gruwel et al. 2005; Ulupinar 1997; Tambychik and Meerah 2010
4.	Detection of validators (Evaluating solutions within the bounds of possibility)	Bransford and Stein 1984; Chen 2010; Shute et al. 2016
5.	Testing the solutions (Deciding the most efficient solution)	Brand-Gruwel et al. 2005; Bransford and Stein 1984; Tambychik and Meerah 2010

maximum possible score of each question was 4 while the minimum possible score was 1. On the basis of this, the highest possible test score was 100 while the lowest possible score was 25. Students were given 60 min to complete the test.

4. Organization of the Environment in which Problem-Based Virtual Learning Materials are Formed

Sessions are the essence of the PBL approach. Learning the pre-planned learning topics through the best possible problems in terms of clarifying the topics is the goal of these sessions (Demirel 2011).

Lesson materials, including the problem-case, that can be used in line with the PBL approach were created in the shape of scenarios in this research. Domain experts' and lesson teachers' opinions were taken while forming the scenarios. Necessary literature reviews on the basis of these opinions were carefully completed. On the other hand, eight basic features that should be in a PBL scenario were determined on the basis of the necessary specific characteristics of scenarios in PBL sessions (Duch et al. 2001; Hoffman 1998; Selcuk and Sahin 2008). "PBL Scenarios Evaluation Expert Opinion Form" was created by the researcher to examine these characteristics. Expert evaluation form with the "Sufficient, Medium-Level and Low-Level" options was conducted on five lecturers in the Science Education Department. E-mails including the learning outcomes of the unit and scenarios besides this expert opinion form were sent to the lecturers. They were required to read each scenario and evaluate them according to the items in the form. In this way, their suggestions about the scenarios were taken; it was thus targeted to ensure reliability.

Scenarios of the unit "Force and Energy" in Science Education Curriculum, was presented to the students according to the PBL session method. Three-session scenario format developed by Saka (2008) was used while creating the scenarios and eight outcomes in the "Force and Energy" unit were taken into consideration. Eight scenarios were written by the researcher in this context. Learning outcomes and Scenarios are presented in Table 6.

During the sessions, students were required to develop solution suggestions for the problem case and reach a solution and answer the questions about the solution by discussing the possible solutions with group members. Questions directed to the students in the first session of the scenarios were about determining the problem case, stating the existing information, finding solution suggestions, limiting solution suggestions by using the newly acquired information, and brainstorming with friends. Questions of the second session were about leading students to determine new information about the problem case and the learning topics that they don't have sufficient knowledge, limiting solution suggestions through discussions with group members. In the third, the final session, students were required to find answers to questions about summarizing the solution of the problem, determining new learning topics acquired during sessions and about the resources used in the process. On the other hand, all groups shared their solution suggestions with other groups at the end of the third session. Experimental group students used a variety of contents about problem cases by using the internet during sessions (Word and PDF files, Photographs, Animations, PowerPoint Presentations, Videos, etc.). Control group students used the resources about Science lessons they have in the classroom.

Table 6 Learning Outcomes of the Unit and the Scenarios

Outcome	Scenario
Mass and Weight Relationship	
1. He/she names gravitational forces that affect the mass as weight.	Let's go to the Space
2. He/she compares the concepts of mass and weight.	
3. He/she explains gravity as gravitational force on the basis of celestial bodies.	Trip to Cern
Force, Activity and Energy Relationship	
4. He/she explains that physical activity is associated with the applied force and distance.	Aunt Hatice and Her Friend
5. He/she associates energy with the concept of activity and classifies it as kinetic and potential energy.	Truck Toy
Energy Transformations	
1. On the basis of the transformation of kinetic and potential energy to one another, he/she draws the conclusion that energy is conserved.	Speed Train
2. He/she explains the effect of friction force on kinetic energy through examples.	Car Race
3. He/she designs a vehicle for decreasing the air or water resistance.	Parachute Accident Boat Race

Mayer's multimedia design principles were taken into consideration while designing the virtual environment used by the experimental group students (Mayer 2009). The virtual learning environment consists of two parts: Virtual learning environment student and teacher module. The student login the student module of the system with username and password; after that, a scenario about the first session is presented to the student. The student is required to identify the problem case, write down what he/she knows about the topic and send his/her file to the teacher. The teacher, on the other hand, controls the problem cases sent by the student in his/her own system, approves the ones he/she sees as appropriate and sends feedback about the ones he/she thinks as improper/ deficient. This cycle continues until the student correctly identifies the problem case. After the student completes the case, he/she writes solution suggestions and saves them in his/her module. He/she makes internet researches about the problem case and finds solution suggestions. The student discusses solution suggestions with his/her group friends and attempts to develop a common solution. He/she finalizes the previously saved solution suggestion by taking the internet research and group discussions into consideration. The first session is completed after these steps and the second session starts. The processes in the first session are repeated in the second session with a new scenario and the third session starts. The student writes the general solution suggestions to the problem cases in the first and second sessions and saves the data. He/she writes the information he/she obtained in the first and second sessions and saves the data. After that, he/she writes the resources he/she used and saves the data. Both the first and the second scenarios are discussed with all students in the class in a discussion environment with the participation of the entire class. On the other hand, in the teacher module, there is a link to a page of approval or correction, in which the teacher analyzes the problem case written by students. There are also links for teachers to reach the student discussion pages.

These scenarios were presented to the experimental group in the virtual environment, to the control group in the classroom environment in written form.

5. Motivation survey

A version of the IMMS (Instructional Materials Motivation Survey) developed by Keller (1979) on the basis of the ARCS model to assess the motivation level of students about teaching practices based on the PBL approach was used in this research. The specific version was translated into Turkish by Kutu and Sozbilir (2011) and named Öğretim Materyalleri Motivasyon Anketi (ÖMMA) in Turkish

The goal of the Instructional Materials Motivation Survey is not to assess the general motivation level of students, but to determine how students are/should be motivated at the end of a specific education process. The original survey includes a total of 36 items; however, as a result of the validity and reliability study, it was determined that it would also be possible to make a reliable assessment by using fewer items. On the basis of this data, the numbers of items were reduced to 24. Although the data collection tool in the Turkish version of IMMS is named as a survey, it has the structure of a scale in terms of content and characteristics. Actor analysis was completed and reliability coefficients were calculated in this scope. The reliability coefficient for the survey, in general, was .0.83; the sub-dimensions reliability coefficients were 0.79 and 0.69 respectively

6. Interview form

Data on student opinions about virtual learning environments were obtained through the use of a semi-structured interview technique. A detailed literature review about the topic was carried out before preparing interview questions. At the end of the review process, draft questions were formed to determine student opinions about virtual learning environments. Expert opinions were collected for ensuring the content validity of the interview form. After obtaining the opinions of the experts, the interview form was finalized; there were a total of four questions in the final version. Pilot tests were carried out with one student from each student in the experimental group to determine the understandability of questions. The purpose of this process was to prevent any misunderstandings about questions. Focus-group, face-to-face interviews were held with the study group students and data were collected; the interviews were recorded with a tape recorder for 75 min.

2.3 Experimental processes

The timeline of the processes in the scope of the research is presented in Table 7.

PBL approach was used for both experimental and control group students through scenarios, during sessions. These scenarios were presented to experimental group students in the virtual environment while they were presented to control group students in the form of written materials in the classroom environment. Before conducting the PBL approach, students were separated into two groups. Each group found a nickname. The problem-based learning approach is a learning process in which the teacher presents students a problem and initially allows them to work on their own. Later, students can participate in

Table 7 Experimental Design Timeline

Date	Process
10.29.2018–11.02.2018 (1st week)	• Measuring Students' Problem Solving Skills Before Experimental Procedure • Informing the experimental and control group students about the PBL approach. • Informing the experimental group students about how to use the virtual learning environment. • Explaining the implementation process to the Science teachers of experimental and control group students, informing them about the PBL approach, showing the data collection tools and scenarios.
11.07.2018–11.09.2018 (1st-2nd week)	• Conducting pre-tests to the experimental and control group students.
Date	Process
11.12.2018–12.07.2018 (3rd, 4th, 5th and 6th week)	• Teaching the lessons to experimental group students in the information technologies lab. Through the virtual environment designed according to the PBL approach. • Teaching the lessons to control group students in a classroom environment designed according to the PBL approach.
12.10.2018–12.14.2018 (7th week)	• Making a general evaluation of the experimental and control group students. • Conducting the post-tests to the experimental and control group students.
12.17.2018–12.21.2018 (8^{th}week)	• Making interviews with 8 students in the experimental group about practices in the virtual environment

discussions of their own groups (Shen et al. 2012). Hence, Students studied in a group in one part of the problem-solving process while they studied individually on the other part.

The researcher was present in the science lesson along with the science teacher. The science teacher gave feedback and guided students in the experimental group with the virtual environment teacher module. Additionally, he/she followed group discussions and directed students when necessary. During this process, the researcher helped the science teacher and ensured students use the virtual environment properly. On the other hand, Science teacher-guided control group students while making researches about the problem case during group studies.

3 Data analysis

Both qualitative and quantitative analysis methods were used in the research.

During the quantitative data analysis process:

Computer Package program was used for the statistical analysis of the data obtained from "Problem-Solving Skill Assessment Test before the Experimental Process" conducted to the experimental and control groups as the pre-test, "Academic Success Test" conducted as pre-test and post-test, "Problem-Solving Skill Assessment Test" and "Motivation Survey". The arithmetic mean and standard deviation values were calculated, normal distribution of the data was controlled and dependent and independent groups t-tests were analyzed during the data analysis process. The meaningfulness level was considered $p < .05$ in statistical analyses.

Difficulty and distinctiveness indexes of analysis results of the test practice, developed by the researcher, were calculated along with the KR-20 reliability coefficient used in the reliability calculations.

Academic success test pre-test and post-test scores were analyzed by independent groups t-test in order to control if the experimental and control groups were equivalent. Before the process of the t-test, the test of normality had been conducted to test if the data distributed normally.

Influence quantity (η^2) was calculated to determine the level of relationship between the dependent and independent variables in the cases when the experimental and control group means had meaningful differences. Influence quantity index variance gives information about the relationship level of the variance with independent or group variable (Buyukozturk et al. 2010). Values suggested by Cohen et al. (1996) were taken into consideration while interpreting the influence size and the values are presented below (cit. Pallant 2017).

- Higher than 0.01 "low-level impact"
- Higher than 0.06 "medium-level impact"
- Higher than 0.13 "high-level impact"

Shapiro-Wilks test was used as the sample number was below 50 in the test of normality used for determining the distribution of the scores obtained from "Academic Success Test" conducted as pre-test and post-test to the experimental and control group students, "Problem-Solving Skill Assessment Test" and "Motivation Survey" (Buyukozturk 2011). At the end of the process, it was determined that the data distributed normally ($p > .05$).

Interrater reliability analysis was practiced to test the reliability of problem-solving skill assessment tests. In this scope, the intraclass correlation coefficient-R1 (intraclass reliability coefficient) was calculated.

During the qualitative data analysis process:

Focus-group interviews conducted with interview forms to the experimental group students were recorded; the voice records were listened to put in writing and analyzed. The content analysis method was used in analyzing the obtained data. This method enables the researchers to reach concepts and relationships that can explain the targeted and collected data. On the other hand, data are analyzed in more detail in this analysis which enables discovering the concepts and themes that cannot be sometimes distinguished by the descriptive analysis (Yildirim and Simsek 2008).

4 Findings

4.1 Findings of the first sub-problem of the research

4.1.1 Findings of the sub-problem: "Is there a meaningful difference between the post-test, academic success scores of the experimental and control group?"

T-test was conducted (as the data distributed normally) to test if there was a meaningful difference between the post-test success scores of the experimental and control group students in the scope of this research problem. T-test results of the experimental and control group students' post-test are presented in Table 8.

Table 8 T-Test Results of the Post-Test Academic Success Scores of the Experimental and Control Groups

Groups	N	$\overline{X}$	SS	sd	t	p	eta-square(η^2)
Experimental	35	75.59	12.35	66	14.69	.000	0.87
Control	33	36.18	9.43				

When the data in Table 8 is analyzed, it can be seen that there is a meaningful difference between the post-test success scores of the experimental and control groups ($t(66) = 14.69$; $p = .000$). Eta-square value calculated for the experimental and control group's post-test success score means is (η^2)0.87.

4.1.2 Findings of the sub-problem: "Is there a meaningful difference between the post-test, problem-solving scores of the experimental and control group?"

T-test was conducted (as the data distributed normally) to test if there was a meaningful difference between the post-test problem-solving skills scores of the experimental and control group students in the scope of this research problem. T-test results of the experimental and control group students' post-test problem-solving skills are presented in Table 9.

When the data in Table 9 is analyzed, it can be seen that there is a meaningful difference between the post-test problem-solving skills scores of the experimental and control groups ($t(66) = 7.39$; p = .000). Eta-square value calculated for the experimental and control group's post-test problem-solving score means is (η^2)0.66.

Mean score distributions of the experimental and control groups' post-test problem-solving steps are presented in Table 10.

Distribution of experimental and control group students' scores obtained according to the problem-solving steps are presented in Table 10. According to the table, experimental group students' post-test problem-solving scores were higher in all steps when compared to the control group students. When the problem-solving steps are taken into consideration, it can be said that that the experimental group students were good at the stages of sensing the problem and identifying it. When the arithmetic means were analyzed, it was seen that detection of validators and testing the solutions were the stages with the highest scores. It was determined that means of developing solutions to the problem and determining the cause of the problem were lower than the means of other problem-solving steps.

Table 9 T-Test Results of the Post-Test Problem-Solving Scores of the Experimental and Control Groups

Groups	N	$\overline{X}$	SS	sd	t	p	eta-square (η^2)
Experimental	35	59.75	11.21	66	7.39	.000	0.66
Control	33	42.50	7.55				

Table 10 Score Distributions of the Experimental and Control Groups Post-Test Problem-Solving Steps

Problem-Solving Steps	Experimental Group	Control Group
Sensing the problem	65.53	44.12
Determining the cause of the problem	54.54	40.53
Developing solutions to the problem	57.00	42.80
Detection of validators	60.41	42.80
Testing the solutions	59.09	42.23
Mean	59.31	42.49

4.1.3 Findings of the sub-problem: "Is there a meaningful difference between the post-test, the control, and experimental groups' lesson motivation levels?"

Dependent groups t-test was conducted (as the data distributed normally) to test if there was a meaningful difference between the post-test motivation levels of the experimental and control group students in the scope of this research problem. T-test results of the experimental and control group students' post-test motivation levels are presented in Table 11.

When the data in Table 11 is analyzed, it can be seen that there is no meaningful difference between the post-test motivation levels of the experimental and control groups ($t(66) = 0.639$; $p = .525$). When the arithmetic means of the groups are analyzed, it can be said that the post-test motivation level average of the experimental group students is $\bar{x}$=98.12 while the post-test motivation level average of the control group students is $\bar{x}$=96. 31.

4.2 Findings of the second sub-problem of the research

4.2.1 Findings of the sub-problem: "Is there a meaningful difference between the control group students' pre-test and post-test academic success scores?"

Dependent groups t-test was conducted (as the data distributed normally) to test if there was a meaningful difference between the pre-test and post-test success scores of the control group students in the scope of this research problem. T-test results of the control group students' pre-test and post-test success scores are presented in Table 12.

When the data in Table 12 is analyzed, it can be seen that there is a meaningful difference between the pre-test and post-test success scores of the control group students ($t(32) = 2.933$; $p = .006$). Eta-square value calculated for the control group students' pre-test and post-test success means is (η^2)0.36.

Table 11 T-test Results of the Experimental and Control Groups' Post-test Motivation Levels

Groups	N	$\overline{X}$	SS	sd	t	p
Experimental	35	98.12	11.88	66	0.639	.525
Control	33	96.31	11.43			

Table 12 T-test Results of Control Group Pre-test and Post-test Success Scores

Groups	N	$\overline{X}$	SS	sd	t	p	eta-square (η^2)
Control (Pre-Test)	33	28.00	11.13	32	2.933	.006	0.36
Control (Post-Test)	33	36.18	9.43				

4.2.2 Findings of the sub-problem: "Is there a meaningful difference between the control group students' pre-test and post-test problem-solving skill scores?"

Dependent groups t-test was conducted (as the data distributed normally) to test if there was a meaningful difference between the pre-test and post-test problem-solving scores of the control group students in the scope of this research problem. T-test results of the control group students' pre-test and post-test problem-solving skills are presented in Table 13.

When the data in Table 13 is analyzed, it can be seen that there is a meaningful difference between the pre-test and post-test problem-solving skills scores of the control group students ($t(32) = 3.661$; $p = .001$). Eta-square value calculated for the control group students' pre-test and post-test problem-solving skills mean is (η^2)0.41.

Mean score distributions of the control group pre-test and post-test problem-solving steps are presented in Table 14.

Score distributions of the control group's post-test problem-solving steps are presented above, in Table 14. When the data in the table are analyzed, it can be seen that the post-test means of control group students are higher than their pre-test means. However, this increase is smaller than the increase in the problem-solving skills of the experimental group students. On the other hand, when the problem-solving steps are taken into consideration, it can be said that the control group students experienced the biggest difficulty in determining the cause of the problem according to the post-test means.

4.2.3 Findings of the sub-problem: "Is there a meaningful difference between the control group students' pre-test and post-test motivation levels?"

Dependent groups t-test was conducted (as the data distributed normally) to test if there was a meaningful difference between the pre-test and post-test motivation levels of the control group students in the scope of this research problem. T-test results of the control group students' pre-test and post-test motivation levels are presented in Table 15.

Table 13 T-test Results of Control Group Pre-test and Post-test Problem-Solving Skills Scores

Groups	N	$\overline{X}$	SS	sd	t	p	eta-square (η^2)
Control (Pre-Test)	33	36.81	4.56	32	3.661	.001	0.41
Control (Post-Test)	33	42.50	7.55				

Table 14 Score Distributions of the Control Group Pre-Test and Post-Test Problem-Solving Steps

Problem Solving Steps	Control (Pre-Test)	Control (Post-Test)
Sensing the problem	35.98	44.12
Determining the cause of the problem	31.62	40.53
Developing solutions to the problem	31.43	42.80
Detection of validators	31.06	42.80
Testing the solutions	29.54	42.23
Mean	31.92	42.49

Table 15 T-test Results of Control Group Pre-test and Post-test Motivation Levels

Groups	N	$\overline{X}$	SS	sd	t	p
Control (Pre-Test)	33	95.70	14.90	32	0.142	.888
Control (Post-Test)	33	96.31	11.88			

When the data in Table 15 is analyzed, it can be seen that there is a meaningful difference between the pre-test and post-test motivation levels of the control group students ($t(32) = 0.142$; $p = .888$). When the arithmetic means are analyzed, it can be seen that control group students' pre-test motivation levels mean is $\overline{x}$=95.70 while their post-test motivation levels mean is $\overline{x}$=96.31.

4.3 Findings of the third sub-problem of the research

4.3.1 Findingsof the sub-problem: "Is there a meaningful difference between the control group students' pre-test and post-test academic success scores?"

Dependent groups t-test was conducted (as the data distributed normally) to test if there was a meaningful difference between the pre-test and post-test success scores of the experimental group students in the scope of this research problem. T-test results of the experimental group students' pre-test and post-test success scores are presented in Table 16.

When the data in Table 16 is analyzed, it can be seen that there is a meaningful difference between the pre-test and post-test success scores of the experimental group students ($t(34) = 18.551$; $p = .000$). Eta-square value calculated for the experimental group students' pre-test and post-test academic success mean is (η^2)0.90.

Table 16 T-test Results of Experimental Group Pre-test and Post-test Success Scores

Groups	N	$\overline{X}$	SS	sd	t	p	eta-square (η^2)
Experimental (Pre-Test)	35	25.40	10.62	34	18.551	.000	0.90
Experimental (Post-Test)	35	75.59	12.35				

4.3.2 Findings of the sub-problem: "Is there a meaningful difference between the experimental group students' pre-test and post-test problem-solving skills scores?"

Dependent groups t-test was conducted (as the data distributed normally) to test if there was a meaningful difference between the pre-test and post-test problem-solving skills scores of the experimental group students in the scope of this research problem. T-test results of the experimental group students' pre-test and post-test problem-solving skills scores are presented in Table 17.

When the data in Table 17 is analyzed, it can be seen that there is a meaningful difference between the pre-test and post-test problem-solving scores of the experimental group students ($t(34) = 14.097$; $p = .000$). Eta-square value calculated for the experimental group students' pre-test and post-test problem-solving mean is (η^2)0.83.

Mean score distributions of the experimental group pre-test and post-test problem-solving steps are presented in Table 18.

The distribution of experimental group students' problem-solving step scores is presented in Table 18. When the data in the table above is analyzed, it can be seen that the highest success rate of the students' pre-test and post-test scores in terms of the problem-solving steps was obtained in the step of 'sensing the problem'. Pre-tests of the students indicate that they had the biggest difficulty in determining solutions to the problem while post-tests indicate that they had the biggest difficulty in determining the cause of the problem.

4.3.3 Findings of the sub-problem: "Is there a meaningful difference between the experimental group students' pre-test and post-test motivation levels?"

Dependent groups t-test was conducted (as the data distributed normally) to test if there was a meaningful difference between the pre-test and post-test motivation levels of the experimental group students in the scope of this research problem. T-test results of the experimental group students' pre-test and post-test motivation levels are presented in Table 19.

When the data in Table 19 is analyzed, it can be seen that there is a meaningful difference between the pre-test and post-test motivation levels of the experimental group students ($t(34) = 4.918$; $p = .000$). When the arithmetic means are analyzed, it can be seen that experimental group students' pre-test motivation levels mean is $\overline{x}$ =82.60 while their post-test motivation levels mean is $\overline{x}$=98.12. Eta-square value calculated for the experimental group students' pre-test and post-test motivation level mean is (η^2)0.41.

Table 17 T-test Results of Experimental Group Pre-test and Post-test Problem-Solving Scores

Groups	N	$\overline{X}$	SS	sd	t	p	eta-square (η^2)
Experimental (Pre-Test)	35	35.25	3.21	34	14.097	.000	0.83
Experimental (Post-Test)	35	59.75	11.21				

Table 18 Score Distributions of the Experimental Group Pre-Test and Post-Test Problem-Solving Steps

Problem-Solving Steps	Experimental Group (Pre-Test)	Experimental Group (Post-Test)
Sensing the problem	36.74	65.53
Determining the cause of the problem	28.59	54.54
Developing solutions to the problem	33.33	57
Detection of validators	29.54	60.41
Testing the solutions	28.40	59.09
Mean	31.32	59.31

Table 19 T-test Results of Experimental Group Pre-test and Post-test Motivation Levels

Groups	N	$\overline{X}$	SS	sd	t	p	eta-square(η^2)
Experimental (Pre-Test)	35	82.60	17.64	34	4.918	.000	0.41
Experimental (Post-Test)	35	98.12	11.43				

4.4 Findings of the fourth sub-problem of the research

4.4.1 Opinions about the virtual learning environments designed according to PBL approach in science lesson

In the frame of this research question, experimental group students answered the question of *"Did the application of virtual learning environments designed according to the problem-based learning approach in science lesson change your opinions about the lesson? If yes, explain the reasons"*. Themes and codes shaped according to the student answers are presented in Fig. 1.

When Fig. 1 is analyzed, it can be observed that all of the students attended the interview stated positive opinions about the use of virtual learning environments

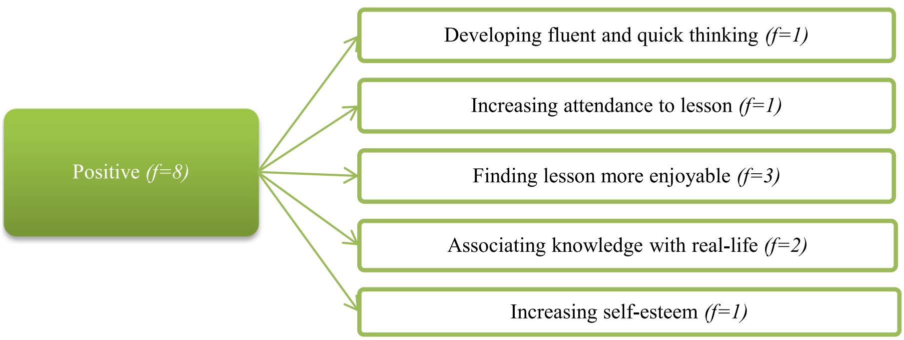

Fig. 1 Opinions about the Virtual Learning Environment Designed According to the PBL Approach in Science Lesson

designed according to the PBL approach. The students specifically mentioned that the lessons were enjoyable. Student DÖ5 said: "*Yes, it has changed. For instance, I didn't like when there were activities in science lessons, but I like it more now*". Student DÖ12 said: "*Yes, it has changed. For instance, before university, I used to think that this lesson was going to be difficult and I wouldn't understand the topic. However, when I started the activity, I understood the topic, solved the tests and had more fun*".

When the opinions were analyzed, it was seen that the virtual learning environments not only made the lessons more enjoyable but also –in a sense- affected the changed thoughts of students about the lesson. Another point that attracted the attention of students and created positive feedback was the association of the scenarios with real-life. Student DÖ22 mentioned these about the issue: "*I now can understand the connection of topics with real-life thanks to the activities*". When the views of students are taken into consideration, it can be said that attendance to lessons increased as students started to find lessons more enjoyable and were able to associate lessons with real-life. Some of the opinions stated by the students support this inference. Student DÖ6 said: *"Yes, it has changed. I used to attend fewer lessons, but now I participate more"*. Besides these opinions, students mentioned that the virtual learning environment supported fluent and quick thinking and increased self-esteem.

4.4.2 Opinions about the activities

In the frame of this research problem, experimental group students answered the question of: "*What do you think about the activities? Explain your opinions with reasons*". Themes and codes shaped according to the student answers are presented in Fig. 2.

When Fig. 2 is analyzed, it can be seen that students had positive opinions about the activities. Some positive feedback are obtained from students about the discussions in the scope of activities. About these discussions, students mentioned

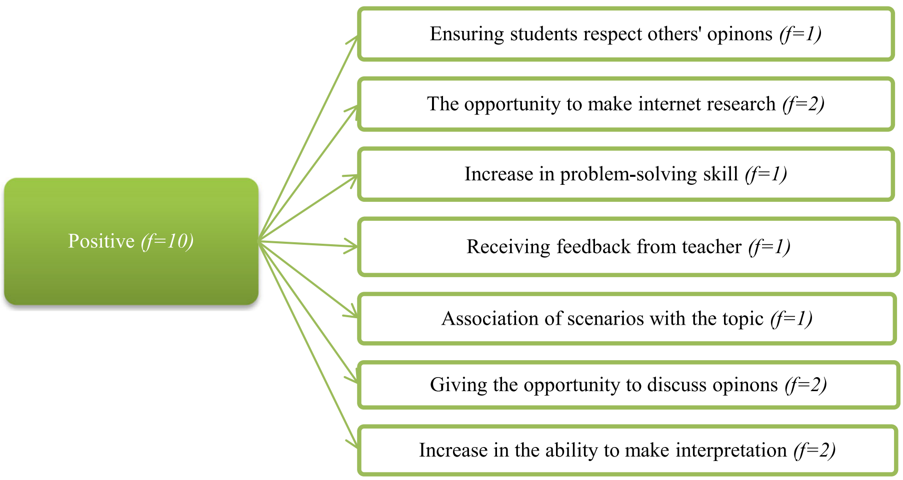

Fig. 2 Opinions about the Activities

that they learnt to respect others, they started discussing personal opinions with their friends and they could reach a common solution at the end of these discussions. About these issues, student DÖ14 said: "*I was impressed by the discussion as I presented my opinions and they presented theirs. At the end of this, we reached a decision and we could find the best answer*". Some of the students mentioned that the process was useful for them as the method presented them the opportunity to conduct online research about their answers after the lesson. Student DÖ30 said: "*The point that attracted my attention the most was that we could make online-researches. We could check to see if our answers were right or wrong*". Besides these opinions, students mentioned that they have positive views about the activities as they increase interpretation and problem-solving skills and teachers give feedback to students through a virtual learning environment.

4.4.3 Opinions about the problem-solving skill

In the frame of this research problem, experimental group students answered the question of: "*Do you think that your problem-solving skill increased by these activities? Explain your opinions with reasons*". Themes and codes shaped according to the student answers are presented in Fig. 3.

When Fig. 3 is analyzed, it can be seen that students stated positive opinions about the issue that activities increased problem-solving skills. The interviews with students indicate that activities increased the problem-solving skills of students, which also positively affected their performances in other lessons. Student DÖ32 said: "*Our ability to interpret the problems has dramatically changed; for example, I started understanding the problems in other lessons more easily*". On the other hand, during interviews, some of the students stated that they started learning better with the increase in their problem-solving skills. Student DÖ12 said: "*I also believe that we have made progress. When I was solving problems before this process, I used to get bored; but when I experienced the virtual environment, I started to have more fun, so I had better results and started learning more easily*". One of the students mentioned that open-ended questions and activities in the virtual learning environment made lessons more enjoyable and had a positive impact on their problem-solving skills.

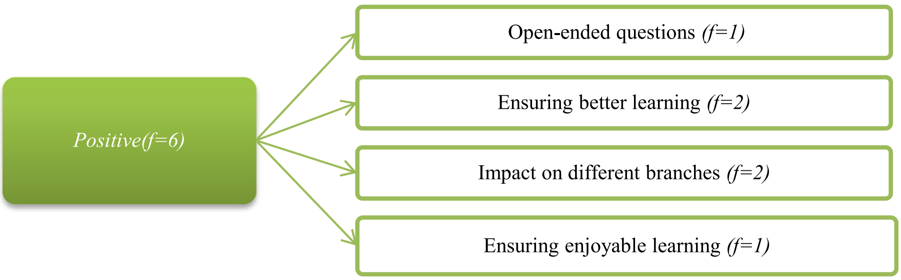

Fig. 3 Opinions about the Problem-Solving Skill

4.4.4 Opinions about the group study

In the frame of this research problem, experimental group students answered the question of: "*What do you think about the group-studies in virtual learning environments? Do you think that they were beneficial? What are the advantages and disadvantages"*. The students had both positive and negative statements about the issue. Student opinions about the advantages of group-studies during activities were collected and the themes and codes formed on the basis of these opinions are presented in Fig. 4.

According to Fig. 4, students had some positive ideas about group-study. The opportunity to check the answers and learn the ideas of other students are the benefits of group-study according to the students participated in the interviews. Student DÖ14 states that: "*I think that the process was beneficial as it gave us the chance to check our answers and see if they were right or wrong. We didn't have this chance before; we used to ask other students and learn their answers to see if our answers were correct"*.

In the interviews, some of the students presented their ideas about the disadvantages of group-studies during activities. Themes and codes shaped according to the student answers are presented in Fig. 5.

Students stated that irrelevant interpretations were specific disadvantages of group-studies. According to the students, such interpretations that have nothing to do with the topic twisted the real arguments. Student DÖ6 said: "*The disadvantage, on the other hand, was that some of our friends said irrelevant things and wrote irrelevant interpretations and they rambled on"*. Student DÖ30 mentioned: "*Some of our friends wrote things that have nothing to do with the lesson, it was unnecessary"*.

Different from the other students, one student stated that group-study decreased his/her self-esteem as his/her ideas weren't taken seriously by the group members. This student, DÖ25 said: *"They didn't take my opinions into consideration, my self-esteem decreased and I didn't participate in group-discussion again"*.

The opinions of the students showed that it is important to take group-discussions and roles of students in these groups into consideration. It can be said that efficient, careful observations and guidance are crucial during the processes of forming the groups and during discussions. It is important to enable each student to take part in group activities, decrease some students' negative attitudes' impacts on the group and individual motivation and make sure that each student properly and completely carries out his/her role in the group.

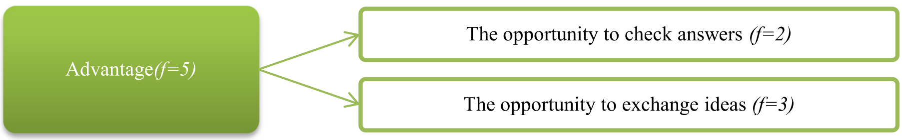

Fig. 4 Opinions about the Group-Study (Advantages)

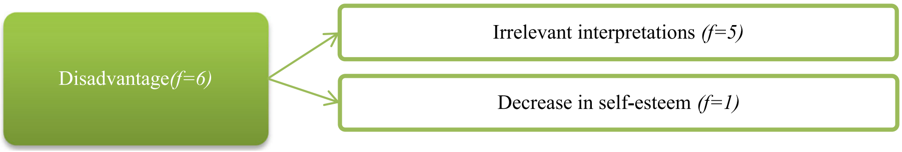

Fig. 5 Opinions about Group-Study (Disadvantages)

5 Results and discussion

In the scope of the research results, it was observed that science lesson academic success and problem-solving skills of students in the experimental group, who received education in the virtual environment, and students in the control group, who received education in classroom environments on the basis of PBL approach, increased.

The results indicate that the experimental group students' mean values were higher than the values of control group students. At this point, the virtual learning environment has an important role. When the related literature is analyzed, it can be seen that there are a variety of studies that compares virtual learning environments with traditional environments; the research findings of such researches support the findings of this research: Virtual Learning Environments have impact on increasing the academic success of students (Barak et al. 2011; Crippen and Earl 2007; Guven and Karatas 2003; Hughes et al. 2007; Hwang et al. 2012; Hwang et al. 2014; Inam and Unsal 2017; Karaci et al. 2018; Kırıkkaya et al. 2016; Ozdemir 2017; Phungsuk et al. 2017). There are virtual environments specifically designed for science and mathematics lessons in many of the studies in the related literature (Aslan and Atici 2016; Karadeniz and Akpinar 2015; Sevim and Ayvaci 2016; Yorganci 2015). Advantages of virtual learning environments such as presenting rich content, developing individual learning, supporting flexibility and time-saving are mentioned in these studies. Current education understanding prioritizes education under the light of constructive and progressive philosophy; modern educators focus on forming individuals who can make research, question what they learn, transform information and who are creative and critical thinkers and can produce solutions to the problems they encounter. The development of technological instruments necessitated the efficient use of technology. Students of today's world take responsibility for their learning and can continue training independent from the time or place; this is why, as can be seen in this research, the positive potentials of virtual learning environments that are properly integrated into different educational processes are highly important.

When the related literature was analyzed, it was determined that PBL approach positively affected students' academic success (Ay et al. 2013; Cetin et al. 2019; Kılıc and Moralar 2015; McParland et al. 2004; Sendag 2008; Tandogan and Orhan 2007; Ulucinar Sagir et al. 2009). The results of this research indicate that virtual learning environments designed according to the PBL approach made meaningful contributions to students' academic success. Although there are few studies in the related literature with contrary findings (Tekedere 2009; Serin 2009), it was determined that there are many reports of studies with different age-groups and lessons, confirming the findings of this study.

Most of the virtual learning environments are designed without taking the educational philosophy and approach into consideration, and they are thus unable to reach success. In this research, the designed virtual learning environment was based on the PBL approach and contributed to increasing the problem-solving skills of students. In the related literature, there are researches indicating that virtual learning environments designed for increasing student problem-solving skills have positive impacts (Altuncekic 2010; Crippen and Earl 2007; Hwang et al. 2014; Kuo et al. 2012; Lee and Kim 2005; Phungsuk et al. 2017; Valentine et al. 2017). When these researches were analyzed, it was seen that according to the data virtual learning environments have positive effects on individual problem-solving developments and they support sharing personal opinions with group members. Moreover, there are studies in the literature showing that PBL activities support developing student problem-solving skills (Aka 2012; Argaw et al. 2017; Gurlen 2011; Mutlu and Ayar Kayali 2018). Besides, the disadvantages of the PBL approach by definition were observed in this research. It takes a long time to prepare and practice the activities, the current computer labs are technically deficient and group-discussions have some disadvantages. It is important to meet the requirements of the PBL approach to make successful practices, just like the other approaches. Topics and lessons should be proper for the group-studies, there should be a sufficient number of students for group-studies, students should be able to reach the necessary resources, and –most importantly- teachers that practice the PBL approach should know the strengths and weaknesses of the technique.

According to the results of the research, experimental group students had higher means in all of the problem-solving steps (sensing the problem, determining the cause of the problem, developing solutions to the problem, detection of validators and testing the solutions) when compared to control group students. Similarly, in a study based on Polya's (1945) problem-solving steps, it was determined that experimental group students' level of understanding problem-solving steps (whose education was based on PBL approach) had a meaningful increase when compared to the control group students (Karatas and Baki 2017).

At the end of the comparison between experimental and control group students' motivation level about virtual learning environments designed according to the PBL approach, it was seen that the change wasn't as expected. There are similar results in the literature that support this finding of the study (Inam and Unsal 2017). In contrast to this, there are some studies indicating that the use of PBL approach in Science classes have positive effects on increasing student motivations (Kılıc and Moralar 2015; Temel et al. 2015; Tosun and Taskesenligil 2012). The motivation levels of students didn't differentiate at the end of the study; it is believed that the activities of the control group had an effect on this situation. Different from the studies in the literature, in which traditional methods were conducted in classroom activities, the PBL approach was used in this study. Accordingly, it is thought that the motivations of the control group students positively affected by the different approaches they experienced instead of the traditional methods usually preferred in classroom environments.

The qualitative results of the research indicate that experimental group students stated positive opinions about the use of virtual learning environments designed according to the PBL approach. It was determined that the use of this environment affected the issue of "finding the lesson more enjoyable" the most. Phungsuk et al. (2017) stated that studying in virtual environments has positive impacts on learning as it encourages learning and eases the communication between teacher and student. On the other hand, it was observed that students found studying in such environments enjoyable and they were satisfied, which in turn increased their success (Hwang et al. 2014; Hwang et al. 2012; Sevim and Ayvaci 2016). Besides, the literature about the use of the PBL approach along with the virtual environment had positive contributions to the opinions of students about education (Manuel and Freiman 2017). The association of scenarios used in the activities with real-life attracted the attention of students, increased willingness of them, supported the development of fluent and quick thinking and increased their self-esteem. The virtual learning environment was enable student to think more fluently and faster by guiding them with its the visual content and instructions. Besides, student was able to discuss the problem situation individually and then express his opinion in the group. This situation hereby increased the student's self-esteem.

When the literature was analyzed, it was also determined that the viewpoints of students about science lessons who received Web-based or Internet-based education methods positively changed at the end of PBL teaching process (Kırıkkaya et al. 2016; Tuysus and Aydin 2007; Yaylak 2010). It was also seen that students had positive views about the PBL activities. Students stated that thanks to these activities, there was increase in their interpretation and problem-solving skills, they had the chance to discuss their opinions, they learnt to respect the ideas of others, they had the chance to make online-researches, they liked receiving feedback from their teachers, and they liked the fact that scenarios in the activities had real connections with real life. It is possible to talk about the effects of advantages offered by the virtual environment to the students in these positive opinions of the experimental group students regarding the virtual learning environment based on the PBL approach. In the virtual environment, students were provided with the opportunity to research on the internet and a visually rich content. Apart from these, the group discussions in the virtual environment were continued more controlled because they were seen on the screen by the teacher. Thus, students are also more motivated to problem situations. In this case, it is possible to mention the positive effects of supporting the virtual environment with the PBL approach. According to the researches about the issue, activities in the scope of PBL practices had significant positive impacts on student perceptions about education (Aka 2012; Altiparmak and Akin 2017; Figueira and Rocha 2014; Temel et al. 2015). When the related literature was analyzed, it was determined that students' problem-solving skills developed when virtual environments were used in lessons (Altuncekic 2010; Kuo et al. 2012; Lee and Kim 2005; Phungsuk et al. 2017; Valentine et al. 2017). It was also seen that students had positive attitudes towards the activities in the scope of the PBL approach, which in turn developed their problem-solving skills (Aka 2012; Argaw et al. 2017; Mutlu and Ayar Kayali 2018; Temel et al. 2015; Yuzhi 2003). It is considered that unlike the materials on the paper used in the classroom environment, the design of the virtual environment used in the experimental group was more attractive and motivating so this affected the students' views.

On the other hand, it was found that group studies were also appreciated by students as students found the opportunity to exchange ideas and check the answers during these studies; however, the irrelevant interpretations during these studies and the decrease in self-esteem because of being ignored by the others are the disadvantages of group studies.

Instead of being passive receivers, students actively participated in PBL activities; they found the chance to learn by doing. They facilitated high-level thinking skills, looked for the answers to questions and felt the team-spirit by participating in group discussions. Besides, students had positive attitudes towards the use of different approaches in classes. This is why; it is believed that it is important to use the practices of this research in other lessons and benefit from the results.

6 Suggestions

Suggestions on the basis of the research results are presented below in two specific titles: "Suggestions about the application" and "Suggestions about the future researches".

Suggestions about the application

- In this research, it was seen that students of the experimental group, who received education in the virtual learning environment based on the PBL approach, had positive viewpoints about the environment and the activities. Based on this fact, it can be said that using this approach in different lessons can support reaching some positive, beneficial results.
- According to the research, some students had negative ideas about group studies during PBL based activities. In order to be able to remove the disadvantages resulted from the misunderstandings in the PBL approach group studies, students can be properly informed, supported and directed throughout these activities, and their cooperation skills, which are crucial in such studies, can be improved.
- Two of the most time-consuming ingredients of PBL based activities are preparing and practicing the scenarios. It requires a lot of time for a teacher to prepare and organize all units in a lesson; this is why, and it can be highly beneficial to ensure the Ministry of National Education to organize the requirements of PBL approach, including the curriculum and books. It can thus be possible to save time and support teachers in training students properly so that they can get the ability to solve problems, which is one of the most significant skills targeted by the PBL approach.

Suggestions for future studies

- In this research study, a PBL based virtual learning environment was used in a Science lesson. On the basis of the related literature analysis data, it was determined that Science lessons are proper for the PBL approach by definition. In this regard, it is believed that using the methodology followed in this research in different lessons can be beneficial.
- Results of the research indicate that students had the best outcomes in "sensing the problem" step; however, they had difficulty in determining the cause of the problem, testing the solutions and detection of validators. Accordingly, it is believed that making careful researches about students' use of problem-solving steps will increase the success of PBL practices.
- Based on the results of the research, it was determined that there were no changes in both the experimental and control group students' motivation levels according to their post-test results. Under the light of this finding, factors that affect their motivation can be determined through quantitative researches.

- Although students had been informed about the PBL approach before the application process, they had difficulty during the practices as they weren't used to the method. It is thought that similar practices with students who have experience in the PBL approach can give different results.
- It is believed that researches about the impacts of virtual learning environments based on the PBL approach on different skills of students can be beneficial in terms of creating specific education programs and they can be used as guidelines in the practices of the PBL approach in the future.

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