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Teachers' Opinions about Intelligent Tutoring System Prepared for Improving Problem Solving Skills of Students

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Abstract
The plenary aim of mathematics education is to bring in mathematical knowledge and skills that are required by daily life to the individual, to teach him problem solving and to bring in him a way of thinking that handles incidents including s problem-solving approach. For this reason, problem solving skills have an important place among the mathematical skills. That problem solving keeps an important place in the overall objectives of mathematics course has carried this issue to the centre of mathematics curriculum at multiple levels starting from primary school. Indeed, NCTM standards, as well, indicate that problem solving skills are needed to be primarily in mathematics teaching (NCTM, 2000). For the solution process of problems, Polya (1957) recommends a framework that contains the stages of understanding the problem, selecting a strategy for the solution, the implementation of the strategy and the evaluation of the solution. The purpose of this study is to evaluate the intelligent tutoring system called as ARTIMAT with the opinions of teachers in terms of contribution to problem solving skills and academic achievements of the students. ARTIMAT, which has been prepared according to Pólya's problem solving steps. In this study case study design which is one of the qualitative research methods was adopted. The implementation, which was conducted in order to evaluate the system, has been performed with 5 teachers in an Anatolian High School. ARTIMAT system has been implemented for three weeks for two hours in each week in computer lab and in a way that each teacher has used his/her own computer. Data was collected administering a questionnaire contained open-ended questions. Descriptive analyses technique was administered on the collected data. In this study presents findings and results of the interviews collected from the participant teachers.

Keywords: Intelligent Tutoring Systems; problem solving; Pólya

Introduction

The basic aim of mathematics education was described as "to bring mathematical knowledge and skills that are required by daily life to the individual, to teach students problem solving and to bring them a way of thinking that handles incidents including a problem-solving approach". For this reason, problem-solving skills have an important place among mathematical skills (Baykul, 2004; De Corte, Verschaffel & Masui, 2004).

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Therefore, this issue was carried to the center of the mathematics curriculum at multiple levels starting from primary school. Indeed, Nation Council of Teachers of Mathematics (NCTM) standards also indicate that problem-solving skills have higher priority in teaching mathematics. Most problems covered under mathematics course are in word form. Word problems help students build new mathematical models and gain experience on this issue. In addition, they prepare a suitable environment for the provision of the language formation, reasoning, mathematical development and interaction among learbers (Reusser and Stebler, 1997).

In this sense, students often solve word problems using direct calculation. They do not think over the content of the problem sentence; because the problems can be solved without deliberating over the importance of problem content in most textbooks (Greer, 1997; Nancarrow, 2004). Thus, students do not often find a relationship between school mathematics and their daily lives. This is because either they have not been taught that there is a relationship, or because they have not been asked to solve problems which allow them to use their real-life knowledge while they make decisions about the solution. If students can be directed to understand the solutions of problems, and to accustom to use the problem solving steps, they can solve and conceptualize word problems more easily (De Corte, Verschaffel & Masui, 2004; Nancarrow, 2004; Nosegbe, 2001). In this regard, Kilpatrick states that; "a student's success in problem solving depends on his development of the skills in problem-solving processes" (Kilpatrick, 1985). Thus, most educators and psychologists carry out research on the structure of problem and problem-solving as well as on how to increase problem-solving success (Cai, 2003).

Of such research, a considerable amount is constitute by applications employing a number of teaching methods and computer technologies (Chen and Liu, 2007; Hoffman and Spatariu, 2008; Li and Ma, 2010; Yen and Chen, 2008). Also in the new mathematics curriculum, computer technologies are considered as one of the basic elements of the program rather than a tool to support the desired change. In other words, computer technologies in mathematics teaching are not regarded as an option, but as one of the components that supplement the curriculum by enabling successful implementation of it (MEB, 2013). Therefore, it requires using not only for developing the students' calculation skills but also improving their level of understanding mathematical topics and concepts and as a tool to develop their problem-solving skills (Jacobse and Harskamp, 2009; Aqda et al., 2010).

In this case, among computer-aided education technologies, the Intelligent Tutoring Systems (ITS) are becoming more and more widespread and gaining more importance since they employ artificial intelligence techniques in order to especially follow step by step the students' learning process, guide them, help in decision-making, make evaluation, identify training needs, help gain knowledge and skills, provide guidance, determine students' mistakes, explain why they made a mistake and to realize individual learning (Huang et al., 2012; McLaren et al., 2010; Jaques et al., 2012; Rowe et al., 2011). The purpose of ITS is to identify students' behaviours, knowledge or errors in order to give them guidance for guiding them to correct their mistakes with the ultimate aim of acquisition of desired behaviours.

ITS must be flexible for both students and the system. The more flexible the system is, the more effective the individual training could be. To ensure such flexibility, the system includes various modules. ITS basically consists of four modules as Knowledge Area Module, Student Model Module, Education Module, and User Interface Module. The studies about ITS show that ITS increases academic achievement and develops positive attitudes of students toward the course. It is also found out in those studies that ITS is capable of generating feedback that may be useful for students and thus it helps learning of the topic well and ensuring a high level of skill development. Furthermore, it was observed that immediate feedback has a significant effect on students' motivation. The results obtained from studies on the use of ITS in problem-solving reveal that step by step solution provides a significant contribution to realize problem-solving through comprehension rather than by heart. In addition, step by step problem-solving allows fully monitoring of the process by both teachers and students (Jaques et al. 2012; Jeremic et al., 2012).

In this study, ARTIMAT, an intelligent tutoring system (ITS), was developed to provide alternative solutions for motion problems. This paper first puts forward design structure for ARTIMAT, then investigates the effect of ARTIMAT to the participants' problem solving and academic achievements according to teachers' opinion. In this study, problem solving is discussed in the framework of Pólya's four problem solving steps.

Method

Research Design

In this study, case study was used as a qualitative research method. 5 mathematics teachers from an Anatolian High School participated in the study. The participants implemented problem-solving activities on their PC by using the student's module on the ARTIMAT. The implementation took 2 hours a week. It was completed in 3 weeks. Following the implementation, semi-structured interviews were held with teachers. During the interviews, the teachers' views were obtained regarding any potential contributions that could be provided by the ARTIMAT for academic achievement and problem-solving skills of learners. Collected data were analyzed with descriptive analysis.

Intelligent Tutoring System (ARTIMAT)

First of all, the study asserts ARTIMAT, which can analyze the problems in accordance with Pólya's problem solving steps on the web. It involves main components of ITS: explanation, knowledge acquisition, inference mechanism and knowledge base.

Modules of ARTIMAT

ARTIMAT has two different modules: "Teacher Module (TM)" and "Students Module (SM)". In the TM, the user can add new problems to the system, update or delete the problems. The main process of the system is solving problems by creating sub-problems for solutions step by step. These sub-problems ("sum of two vehicles," "difference of distances" ...) are stored in the database. The students' module includes motion problems prepared for students. Students can study with the exercises which are prepared by the system. Problems are organized by the system according to the responses of students. In addition, these problems can be used as exam problems by the teacher.

Student module

The Student Module is one of the main modules for students' training and practicing on motion problems. The sub-modules of SM are shown in Figure 1.

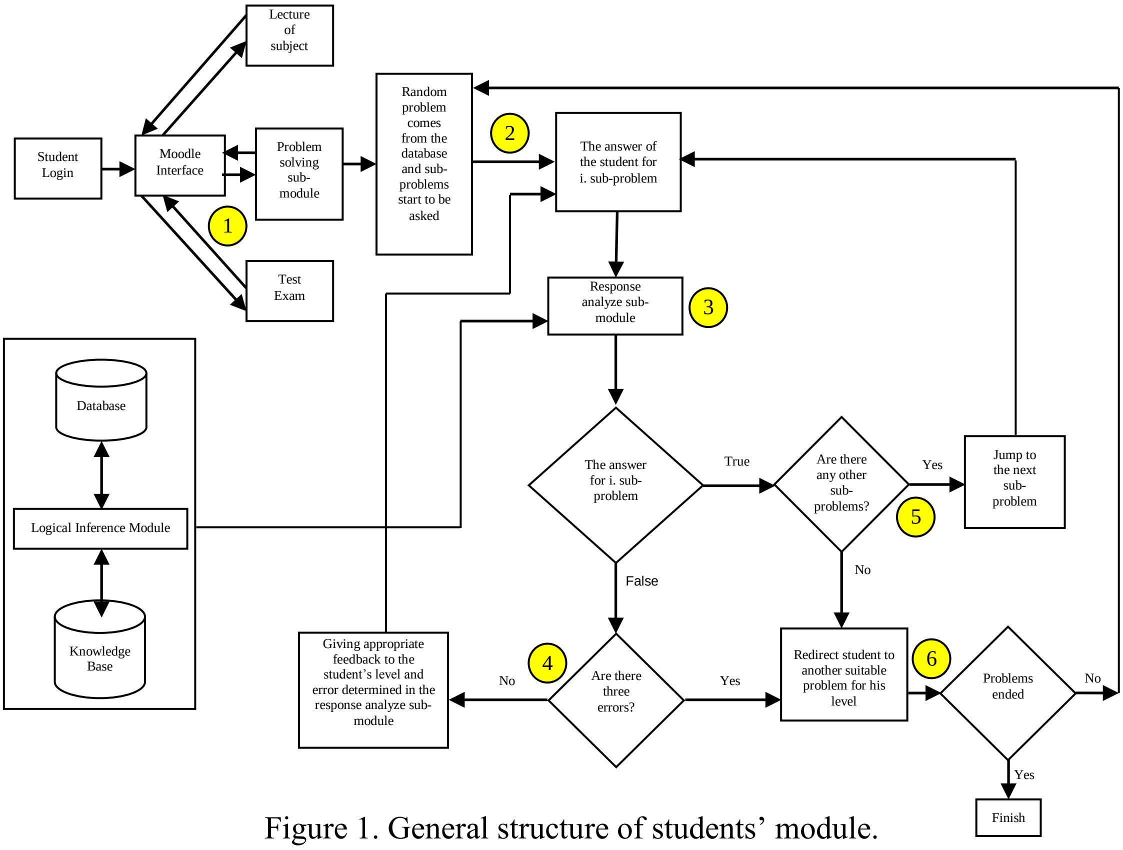

Figure 1. General structure of students' module.

(1) Students enter the system by authentication. They call for the lecturing page or web page for problem solving or test exam.
(2) In the Problem Solving Sub-Module, all motion problems are grouped by level of difficulty. During the first signing in, ARTIMAT randomly selects the first problem from the moderately difficult group.
(3) In the Response Analyze Sub-Module, after analyzing the student's responses for the first problem, new problems are selected by ARTIMAT among upper or lower level problems according to the answers. Then the student is directed to this newly selected problem.
(4) If the student's responses are correct according to the sub-problems, ARTIMAT passes to the next step and directs the student until the final result.
(5) When the student gives a wrong answer, the system gives feedback and asks for a new answer.
(6) If the student answers wrong again, the ARTIMAT selects another problem from the lower level group. By the time the student gets to the correct final solutions, the difficulty level of the question increases; in contrast, if student gets it wrong, the level decreases.

These six steps of SM together support students in solving the problems by following Pólya's problem solving steps and to giving appropriate feedback. The relationship between the steps that students follow in ARTIMAT and Pólya's problem solving steps is shown in Figure 2.

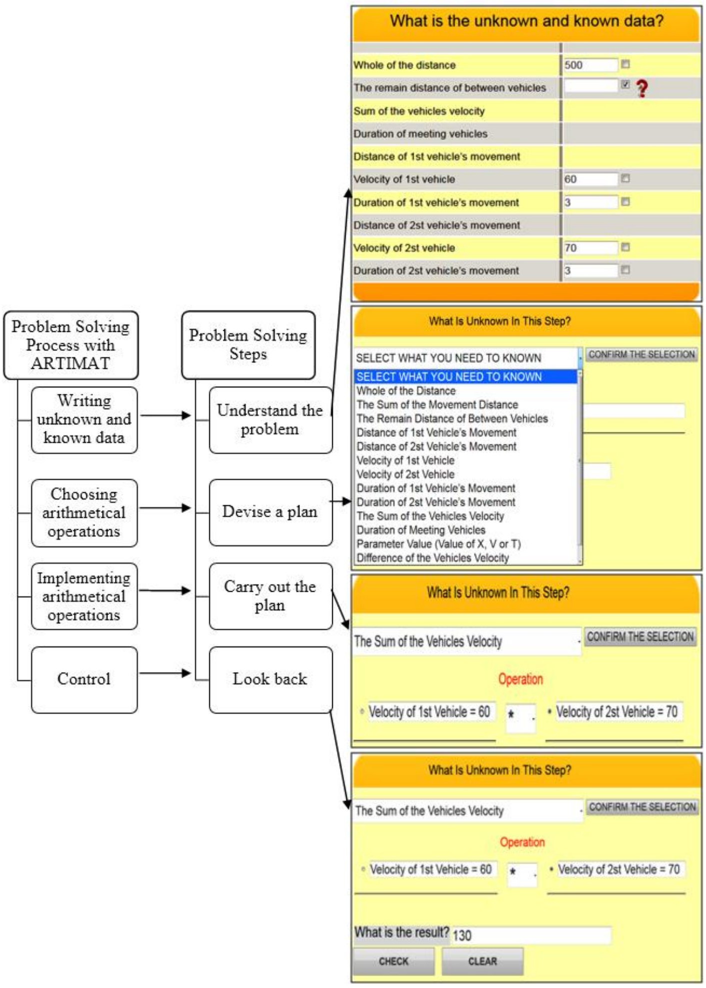

Figure 2. Problem solving in ARTIMAT and association of Pólya steps

In the Problem Solving System of ARTIMAT, there are several factors of motion problems taken into consideration: number of vehicles, number of positions, direction, time and variations of start point and also including parametric or nonparametric structure. In this sense, ARTIMAT has a guiding role in two cases (having a parametric or nonparametric structure) for solution of problems. For each case, it analyses 10 different types of problems. The characteristics of the problems are listed in Figure 3.

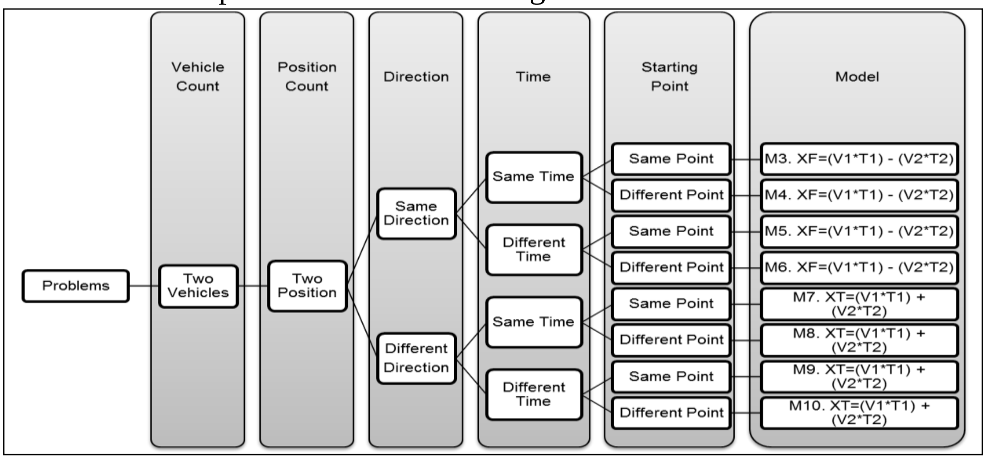

Figure 3. The characteristics of the motion problems which can be solution of ARTIMAT

Also ARTIMAT can solve problems taking the following variables into consideration: The number of vehicles (one or two) and direction of the motion (opposite or same directions), starting time (same or different). Below, a sample problem is provided including two vehicles moving from different points at the same time to opposite directions. ARTIMAT provides an environment for students to solve problems according to Pólya’s problem solving steps.

> Sample Problem: Two vehicles have a distance of 500 km between them. They move towards each other at the same time at 60 km/h and 70 km/h velocity. What is the distance between them after three hours?

1-Understanding the Problem: At this step, the student is asked to enter the known data and asked to check the unknown data. If the student cannot reveal the known and unknown data, s/he gets feedback (Eg: 1. *You have entered the velocity of vehicle wrong*.) about the mistake and informed where s/he has a mistake. If all the data is entered correctly, a congratulation message is sent and then the system passes to the second step. This process is done by ARTIMAT by comparing the correct data with the data entered by the student. A view about this step is depicted in Figure 4.

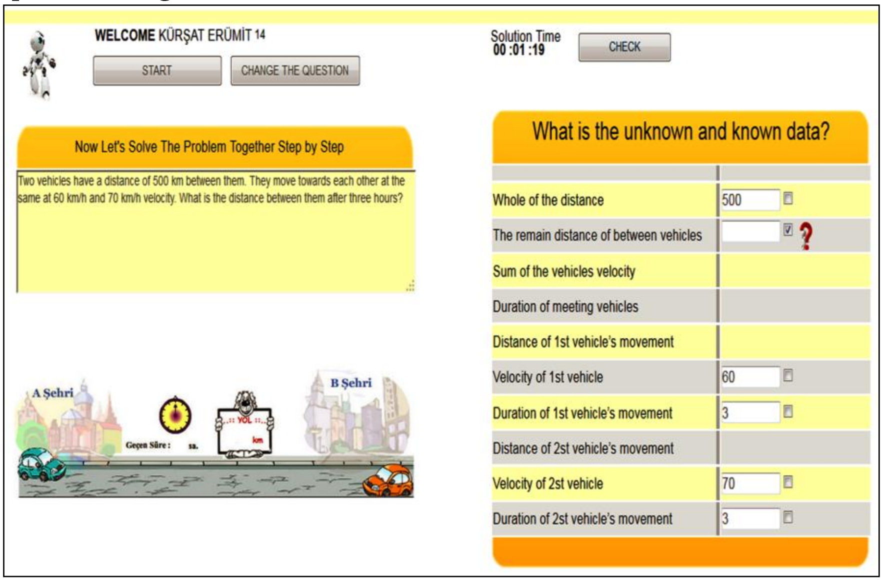

Figure 4. The data-enter screen of the system.

In Figure 4, under the heading “What is unknown and known data?”, the blank spaces for students’ data input are constructed automatically by ARTIMAT which is specific to the problem that is addressed to the students. Students can enter in these spaces not only a number but also the parametric values depending upon the given problem. Motion problems have various types of problem according to the situation of the motion: single vehicle, two vehicles, etc., the direction of motion: same, opposite direction and the time of motion: at the same time, different time and so on. It is considered that presenting all the alternatives related to these types of problems in one scene may cause cognitive load by reducing the comprehensibility due to complexity of designing. Thus, we illustrated the steps followed in the solution process in different scenes.

In the sample problem, the student has to enter the data as given below:
Velocity of 1st vehicle: 60 kms/h
Velocity of 2nd vehicle: 70 kms/h
Duration of 1st vehicle’s motion: 3 hours

Duration of 2nd vehicle's motion: 3 hours

Whole of the distance: 500 kms

2-3-Selecting and Implementation of Strategy for the Solution: This step includes operations for the problem solution:

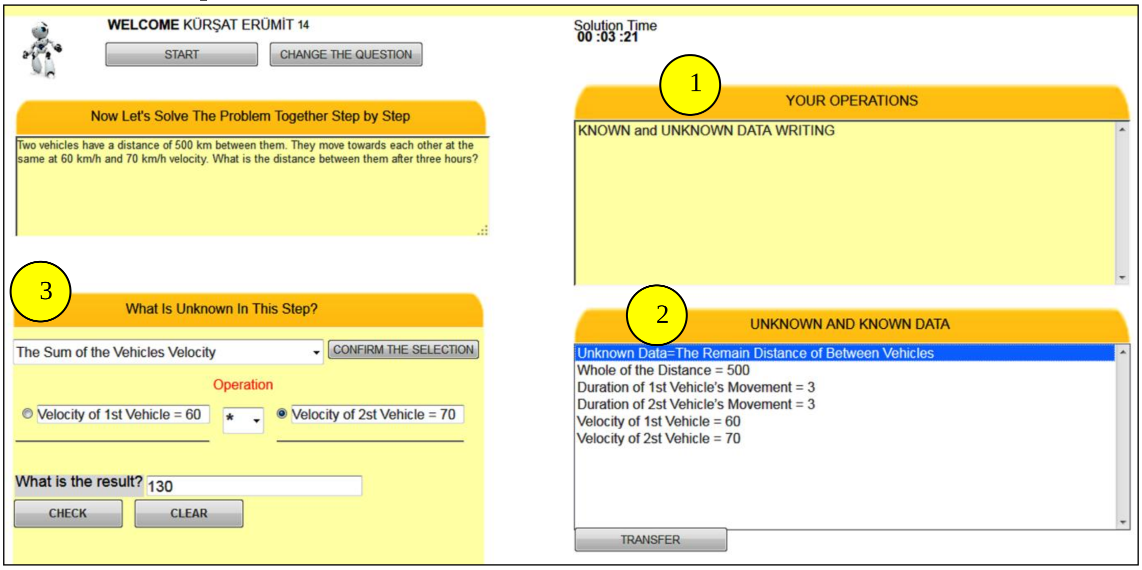

Figure 5. Implementation of strategy

(7) There is the list of operations in the tab of "Your Operations" including all the operations the student has gone through up to this step. Also the correct and false operations are distinguished with the colours in the list.

(8) The "Unknown and Known Data" is the list in which the unknown and known data in the problem is shown. While solving the problem, the items on this list are used in the operation by the student. If the result of the operation is true, it is inserted to the list by ARTIMAT.

(9) The part "What is unknown in this step?" is a part in which the student selects the correct operation and applies the correct operations for the solution. In addition, the result is checked by ARTIMAT. After the student selects the requirements at the end of the operation after that step in "Select what you need to know?" part, required values that are unknown and known in the "Required to be known and found list" are transferred to the operation part and the result of the operation entered by the student is checked by ARTIMAT. The result of the arithmetical operation which is selected from the "Operation" part is selected by the student. This operation is not done by ARTIMAT to check whether the student has a problem in arithmetical operations or not. If a false step is selected in "Select what you need to know" list, the student is warned as "Incorrect operation step". If the student selects the incorrect input even if the step of the operation is correct that is required to be used in the operation, s/he is sent a message that something is wrong with known or unknown data.

In this part, there are all the possible options that student can select for the solution within motion problems in the "Select what you need to know" part. This list is constructed by ARTIMAT in a way that the problems can change according to the type of motion problem asked for the student. In other words, the list has a dynamic structure according to the problem. By this means, unnecessary alternatives aren't listed considering they can cause cognitive load for the student in the operation process and may not be suitable with the problem type. It is seen that in ARTIMAT some operations are done by the user, while some are done by the software.

4-Evaluation of the Solution: In this step, ARTIMAT checks for the mathematical operations in all steps. If all operations are correct, then the student is allowed to go on to the next step; otherwise, s/he is warned by a message about the mistake. Thus, the student is supported to check for the solutions in every operation.

The student has three rights to make mistakes during the problem solving process. S/he is warned with a message for each mistake. After three mistakes, the student is directed to a one-level easier problem. When the student solves the problem correctly, s/he can pass to a one-level upper problem. The records such as the student's steps in the solution of the problem (Ex: Entering data, selecting the unknown data, selecting what is required, operations, checking the result), the duration of solving of the problem, date of entry to the system, the number of correct and wrong answers and their total points are all stored in the system's data base. Stored data is referred to find out where the student's mistakes occurred.

Findings

This section displays the findings obtained from the semi-structured interviews conducted with 5 teachers using the ARTIMAT. Some demographic characteristics of the participating teachers are given in Table 1. The participants were instructed to indicate their computer use in classes on a 5-point scale ranging from 1- I never use; 2- I rarely use; 3- I sometimes use; 4- I often use; 5- I usually use.

Table 1. Demographic Data regarding Participants

Teacher (K)	K1	K2	K3	K4	K5
Gender	Male	Female	Male	Male	Male
Period of service	21 years	13 years	15 years	18 years	16 years
Level of Graduation	Bachelor	Bachelor	Bachelor	Bachelor	Bachelor
Frequency of using computer Technologies in lesson	4	5	3	3	3
Attendance in the course on the use of smart board	Yes	Yes	Yes	Yes	Yes

As seen in Table 1, the shortest service of period reported by participants is 13 years. Additionally, all participants benefit from the computer Technologies during in their courses. Again, they all attended training on how to use the smart board as a part of the FATİH Project.

These findings indicate that the participants are well versed in mathematics education. In addition, it is understood that they are aware of computer Technologies and they are willing to adapt these technologies to their courses.

The teachers were asked "*What impact do you think the ARTIMAT has on students' developing their problem-solving skills*?" The question was posed with the intention of obtaining information regarding the potential contribution of the ARTIMAT to problem-solving skills of students. The findings obtained from teachers' views are given in Table 2.

Table 2. ARTIMAT Contribution to Problem-Solving Skills

Teachers' Views	K1	K2	K3	K4	K5
It provides contribution to problem-solving skills	√	√	√	√	√
It provides contribution to problem-solving by understanding	√		√	√	√
It allows determining differences of solution at each stage	√				
It teaches how to use and think of different solutions	√	√		√	√
It allows solving problems more easily	√		√		
It allows solving problems accurately		√		√	√
It facilitates solving problems in traditional environment		√	√	√	
It improves capability of processing			√		
It ensures compliance with problem-solving steps			√		

According to Table 2, the participants K1, K2, K3 and K4 pointed out that the ARTIMAT improved the students' problem-solving skills as cited below:

K1: "…in particular it will contribute to students in relation with understanding the question. Additionally, I think it will help students understand the steps of problem-solving and improve their math problem-solving skills as it tests if the transaction is correct or wrong and gives students the chance to overcome the mistakes by sending warning."

K2: "…it develops students' problem-solving skills, because students do not investigate the data ready in the system, they just refer to and use them. They evaluate the results in hand. So, it becomes easier to learn and solve the problem"

K3: "Now I find it positive as it helps understanding the problem and following the steps of transaction. I see it as an effective project for understanding the problem... Students will then realize the same steps on paper, I think. I mean, once it is learned what was given, what was asked here, which transaction we will begin with, how we will continue; it will be more comfortable when solving on paper... better learning will take place thanks to the visual items…."

K4: "Children solve problems step by step here. For instance, when he solves any step accurately, he can be happy at that stage; when he solves one stage without solving the whole problem, he can then go to other levels thanks to motivation and it can provide a benefit for him."

"…It helps tracking data on the ARTIMAT and tracking data on the problem as well. It also helps them transfer these skills onto paper. Then, he can transfer the data onto the paper in the same way as he sees on the computer; that is, he can put on paper the problem solution in a more systematic way."

In general, all of the participants pointed out that ARTIMAT supports students think analytically, helps them acquire and develop problem-solving skills, takes them away from memorization and guides them to reason.

In following stages of the study, some questions were asked in order to find out the reasons for the contribution to the students' academic success by ARTIMAT. The participants were asked following questions:

- "How do you assess that the ARTIMAT shows different ways in solution of problems? Do you think this property will be an impact on student achievement?"
- "Do you think ARTIMAT can provide enough guidance for students during problem solving? Please explain. What kind of features would you like to include if you have suggestions?"

- "Considering the process steps to be followed when solving a problem, assess the steps of process advised by ARTIMAT during problem solving."

It was aimed at identifying the reasons for the effect of the ARTIMAT on academic achievement of students. The data obtained from the participants are shown in Table 3.

Table 3. Teachers' Views regarding Reasons for the Contribution of ARTIMAT to Students' Academic Achievement

Teachers' Views	K1	K2	K3	K4	K5
It allows self-assessment	√	√		√	√
It allows testing accuracy at every stage	√	√	√		
It allows students to check their knowledge	√			√	
It allows discontinuing the wrong transaction	√		√		
It provides guidance		√	√	√	√
It allows students to learnt different ways of solution		√	√	√	
It provides motivation at every stage	√	√	√	√	
It allows advancing step by step		√		√	√
It allows realizing of the points where mistake is made				√	
It addresses to students with different learning models	√				√

In relation with findings in Table 3, some of the teachers' remarks are given below:

K1: "As it runs following an inaccurate operation, it is quite good that it goes back and checks the information from the beginning again without continuing the wrong operation."

K2: "It is good that the system guides you. So, as you enter the data correctly, it directs also when you enter the wrong data, and this makes our job even easier while solving the problem, I think. At least it gives warning and guides accurately you if I make a mistake. I frankly like the steps of the system. I found it a better guidance than the classical system."

K3: "…I think it would be a positive effect on the success of the students. In my own courses, I give a number of different solutions to the problem not only in this matter but also all other matters. Even if he cannot understand one, he can understand another. Solutions also vary from person to person, so I'm writing it all. I do it so that they solve it in the way they like. It shows that there are different ways in the system. This is a good thing."

"…You enter the data of the problem, you get what is asked, if you make a mistake at that point, it gives warning. It gives necessary notices during the operation; namely, the guidance is enough; you enter what is given and what is asked of you; if you enter it wrong, it tells you where you made a mistake."

K4: "…Of course, solving the problem not only through one way but various ways might show the child that there might be other ways of solution than the one in his mind. So, one way could lead to memorization, but if he is able to solve through a number of ways, it means that he can comprehend the subject. This system takes away the child from memorization."

"…It shows the mistake, sends warning. For example, after correcting the mistake, it goes to other level, which is good. As the student goes from simple to difficult question, if he can solve the problem gradually, there it could give him a thrill and he may want to solve more problems as he continues. This can also increase his motivation."

"…Also regarding measurement and evaluation, the system might provide exact information about solving problems. How much could the student understand, how good is his process ability, how is his ability to solve, the ability to think, it can give detailed information all about these"

"…For example, this is the logic in games; in computer games also you're going through a stage to the second stage. You can progress as you enter the data and do it accurately at

> the second stage, and you like this. You want to proceed to the second one, but if you make a mistake, it warns you to correct it."
> K5: "It is well that the system provides guidance and it assesses students. It is good that the system warns when something is entered incorrectly."
> "…In some of the students it may create ease in the learning of pupils who learn in different way."
> "…The system is also useful in assessment and evaluation; so, it is beneficial for our job because they usually ask us to analyse tests."

Participants K1, K2 and K4 reported that the ARTIMAT tests accuracy of the steps of operation, hence it allows students to check the data during problem-solving so that they can try another way without continuing the wrong operation thanks to the guidance provided. They also stated that it is useful for students that the system warns the student in wrong operations and shows the steps of the operation in the case of failure, and it also allows students to evaluate themselves. K3 stated that the system gives students the chance to choose their own solutions, it shows the steps of operation which were made incorrectly and guides the student correctly, it guides to easy ways of solution and the time elapsing for solving of the problem can be seen. The participant added that especially the feedback on the system increases students' motivation. K4 and K5 reported that the system directs students to problem-solving steps to reach the solution and provides assessment and evaluation of the students. In addition, K4 stated that the system teaches progressing step by step in problem-solving and it is capable of correcting the students' mistakes at the same time, thus is it beneficial and it motivates students in all stages of the problem solving process. Furthermore, K5 said that the system is suitable for being used by students with different learning styles.

Discussion and Conclusion

It is seen that the mental process experienced in problem-solving contains understanding the information, building the relationship between the information, thinking in a critical, creative and reflective way, and using analysis and synthesis skills (Soylu and Soylu, 2006). Effective realization of this process depends on development of students' problem-solving skills (De Corte, Verschaffel & Masui, 2004; Karataş and Güven, 2004). In order to develop problem solving skills, the use of computer-aided learning environments is becoming widespread. Most studies report that computer-aided instructional materials contribute to students' problem solving skills and academic success, hence they seem to be extremely important to design.

Computer supported problem solving systems usually combine all steps of the solution in one step (Huang et al., 2012). In these kinds of systems, some challenges were noticed for students to be aware of their mistakes in problem solving. The main limitation is the lack of detecting where students make mistakes. Thus, such systems cannot give them appropriate feedback to continue problem solving. So these systems cannot go beyond being supplementary and motivating means in teaching mathematical problem-solving (Lopez-Morteo & Lopez, 2007; Huang et al., 2012). The most important criticism of Huang et al. (2012) on such systems is that their effectiveness in the implementations on real learning environments experimentally is not clear. Hence, this study has provided students an opportunity to see step by step where they make mistakes during problem solving.

In this regard, ARTIMAT primarily solves the problems recorded on the database in different ways automatically. It records the result of the solution in each step. ARTIMAT can compare and check each step of the student's solution with its own solution and can present appropriate feedback or direct them to a different question. As is known, researchers suggest that ITSs should focus on individualization by allowing determining individual needs and generating solutions for these needs. ARTIMAT with its affordances supports these suggestions.

This study provided some evidences about the positive affect of ARTIMAT in which the students have used it and have had higher performances on the process of problem solving. Most of the students have prevailed such properties facilitated the problem solving process, motivational, easy to use and comfortable. In a study about ITSs in Taiwan, researchers have prepared an ITS for Primary School students by using steps of the problem solving process (Huang et al., 2012). As a result, they found that the problem solving skills and motivations of the participants were enhanced. Similarly, ARTIMAT indicated that it isn't easy to gain specified opportunities of ITSs in a traditional class environment.

The process of problem solving requires thinking analytically and proceeds in a hierarchical structure. If the teacher implements problem solving activities at irregular steps, this may cause the students not to comprehend the solution exactly (Bransford & Stein, 1993). So, using ITSs in problem solving should focus on the process instead of providing results directly. If result-based evaluation methods are used in problem solving process, the evaluation only focuses on the correctness of the results which are true or false (Gooding, 2009; Tambychik & Meerah, 2010). Therefore, challenges for the student in the problem solving process cannot be identified thoroughly (Merriënboer, 2013; Lee, Shen, & Tsai, 2008; Blatchford et al., 2011). This also directs the students not to care about the solving process. They try to reach the result in the shortest way, memorize only formulas and ignore building up relationships in problem solving process (Molnar, Greiff, & Csapo, 2013; Chingos, 2012; Thomas, 2012). In contrast, Pólya (1957) suggests while solving a problem, the steps that students follow for the solution should be more didactical. ARTIMAT was a typical example which focused on the process and avoided students from memorizing. Students get addicted to use Pólya's steps by using ARTIMAT. They have corrected their mistakes by checking their responses due to ARTIMAT's supportive feedback. As some studies suggest, feedback in the ITS motivated students during the process and helped them understand the availability of the operation done and evaluate themselves (Chen et al., 2008; Blatchford et al., 2011). In this study, the qualitative data showed that the process in an ITS produces more performance for students' problem solving.

As a conclusion, it was found out that the ARTIMAT could contribute to problem-solving skills as follows:

- It contributes to the students' problem-solving skills,
- Since it is process-oriented, it takes away students from memorization,
- It contributes to understanding problems and facilitates solving problems,
- It gives a different perspective on problem solving,
- It helps students realize that there might be different ways of solution and apply different ways for problem-solving,
- It teaches students how to use the different solutions so that they can perform other ways of reasoning than linear reasoning.

Our study examined the reasons for increasing of students' academic success by the ARTIMAT in the light of the findings obtained from the interviews with teachers. As a result, following conclusions were reached.

- It gives students a process-oriented method to solve the problem by which students can be better problem solvers with this method,
- It makes it easy and fun to solve problems by providing simplicity and clarity in problem solving,
- It increases students' level of motivation by giving them the sense of achievement,
- It helps better understand, interpret and answer questions,
- The ARTIMAT prevents wrong learning by giving instant feedback in the case of mistake at every stage of problem-solving. In right operations, it both motivates learners and reinforces learning by means of feedback it gives instantly.

In future studies, students' cognitive processes can be compared in traditional implementations and in problem solving on ARTIMAT. The results of this study may have provided a light for other problems in various subjects. Also the problem solving way of our study can also be used in other ITSs by adopting it to other areas of problem solving.

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