AN ARTIFICIAL INTELLIGENCE-BASED DISTANCE EDUCATION SYSTEM: Artimat

Prof. Dr. Vasif NABIYEV,
Doç. Dr. Hasan KARAL,
Doç. Dr. Selahattin ARSLAN,
Lecturer Ali Kürsat ERUMIT,
Res. Assist. Ayça CEBI,
Karadeniz Technical University,
Trabzon, TURKEY

ABSTRACT

The purpose of this study is to evaluate the artificial intelligence-based distance education system called as ARTIMAT, which has been prepared in order to improve mathematical problem solving skills of the students, in terms of conceptual proficiency and ease of use with the opinions of teachers and students.

The implementation has been performed with 4 teachers and 59 students in 10th grade in an Anatolian High School in Trabzon. Many institutions and organizations in the world approach seriously to distance education besides traditional education. It is inevitable to use the distance education in teaching the problem solving skills in this different dimension of the education. In the studies in Turkey and abroad in the field of mathematics teaching, problem solving skills are generally stated not to be at the desired level and often expressed to have difficulty in teaching.

For this reason, difficulties of the students in problem solving have initially been evaluated and the system has been prepared utilizing artificial intelligence algorithms according to the obtained results. In the evaluation of the findings obtained from the application, it has been concluded that the system is responsive to the needs of the students and is successful in general, but that conceptual changes should be made in order that students adapt to the system quickly.

Keywords: Distance Education, problem solving, artificial intelligence.

INTRODUCTION

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 problem solving approach. For this reason, problem solving skills take important place among the mathematical skills (Baykul, 2004; De Corte, 2004). That problem solving keeps an important place in the overall objectives of mathematics course has carried this issue to the center of mathematics curriculum at multiple levels 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.

Within this framework in many studies students are indicated to encounter a number of difficulties in understanding the concepts that problems include and the relationships between the concepts while they are solving problems (Ben-Hur, 2006; Chiu & Klassen, 2008; Inzunza, 2006; Simon et al., 2004; Vicente, Orrantia & Verschaffel, 2007). According to Polya, one of the most important causes of these difficulties is that students do not perceive problem solving as a gradual process. This opinion is supported by some studies.

Therefore, mathematics educators have a consensus on developing students' problem-solving skills and on issue that education should be prior aim (Cai, 2003; Karataş & Güven, 2004). For this reason, problem and the structure of problem solving, and increasing the success in problem solving is an issue studied by many educators and psychologists (Cai, 2003; Kılıç & Samancı, 2005).

In addition to many teaching methods, applications using computer technologies keep an important role in these studies.

Now, many institutions and organizations in the world are seen to approach seriously to distance education besides traditional education. Especially after equipping universities with computer networks, it has been inevitable for the academic staff of universities to have interest for the distance education as distinct from the traditional education (Pala, 2006). Healing of technological infrastructure for internet-based distance education every day, eliminating of barriers of time and place for education, having opportunity to reach a wide audience and data's being continually updated has made internet-based education attractive (Kantar et al., 2008).

It is emphasized in the new mathematics curriculum that student can construct his mathematical knowledge in accordance with the nature of constructivist approach, which is adopted by the program, using the software provided in an interactive way. Students should be encountered problems with different characteristics by analyzing problems that are primarily presented in the computer environment in the context of developing the problem solving skills. To accomplish this, software to enable student to live solution stages by presenting feedback according to the solution of the student is needed. Of course, programmability and availability of the software is also associated with the chosen topic.

As computer does not have the possibility to think and make decisions in the proficiency of human, it is being usually worked on issues which are possible in terms of viability. Motion problems have an important place among the topics of mathematics curriculum related to problem solving due to that they contain questions of different types, the use of different solution ways and non-routine problems. Therefore, presentation of motion problems by an expert system in a way that they provide student to live problem solving processes will be a usable example in the field.

"Expert Systems" is a software system that models the processes of judgment and decision-making of one or many people who are experts in a particular subject. Man acquires new knowledge throughout his life, deepens his views over time, changes and matures. Similarly, expert systems can broaden knowledge base and get rid of re-writing of the programs in the attachment of information. To be named a system as an expert system, it should have the abilities of detecting the errors of the user and directing the user by finding the mistakes (Nabiyev, 2005).

For this purpose, the present database of the expert system can be broadened according to the needs. In addition, the system can make logical deductions and it can be updated by field expert. In the light of given data, the purpose of this study is to evaluate the expert system called as ARTIMAT, which has been prepared in order to perform an education in which problem solving process gains importance to improve problem solving skills of the students and logic of problem solving is taught through a computer, in terms of conceptual proficiency and ease of use with the opinions of teachers and students.

MATERIAL AND METHOD

The Expert System Software: ARTIMAT

General structure of ARTIMAT

The general appearance of designed system is given in Figure: 1 The system has been designed in different modules for different types of users in it.

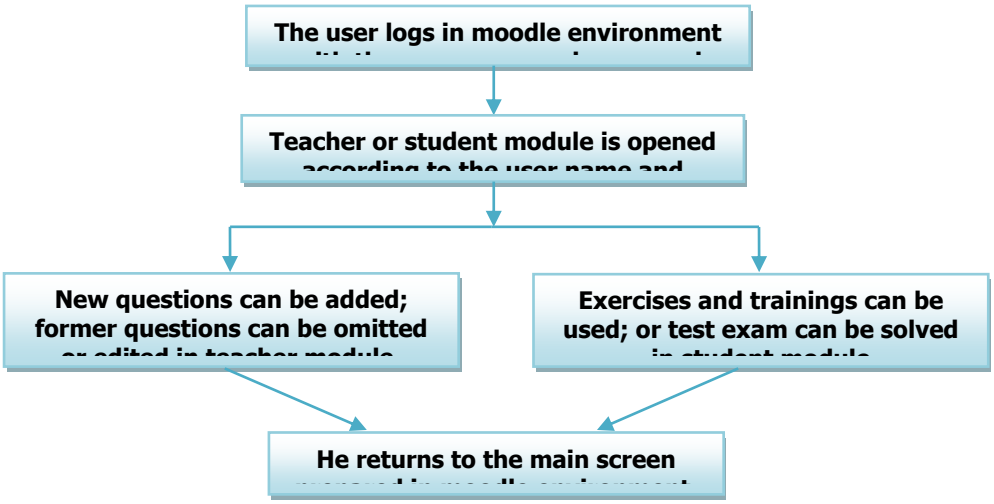

Figure: 1
General Structure of the System

The system includes two different modules for two types of users, teacher and student. Different interfaces are opened in the entries of teacher and student in the system.

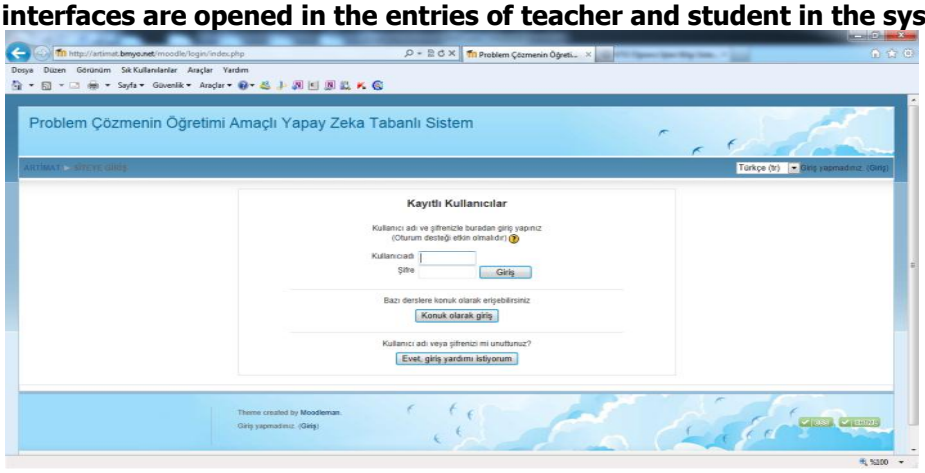

Figure: 2 Moodle Login Screen

In general; routing is done to teacher or student interfaces according to the user name and password in the entrance with the user name and password in the main screen prepared in Moodle environment. In teacher module, the user can add a new exercise or test problem to the system; can edit and remove former problems. In student module, the user can solve test exam using the education and exercises about motion problems. The schematic representations and explanations of the functioning of both of teacher and student modules are given below.

Teacher Module

Teacher module (Figure 3) is a module that user can add exercise and test problems, edit or remove former problems in the database when he logs in.

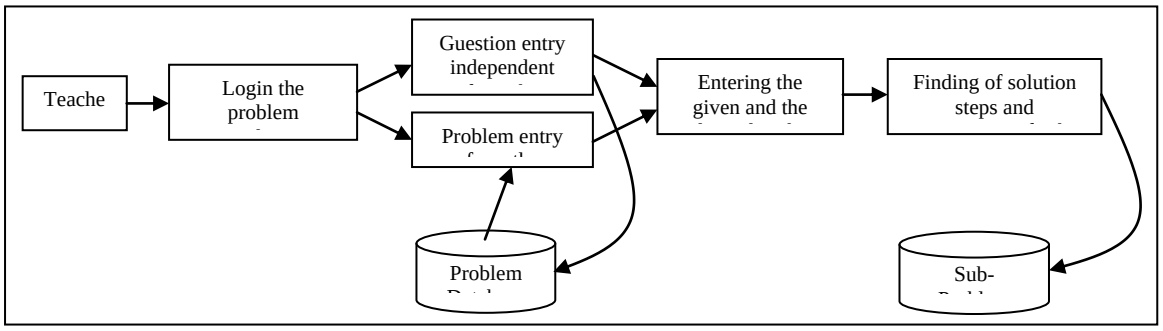

Figure: 3
The General Structure of Teacher Module

The user firstly logins to the system through Moodle interface. The user who logins through Moodle interface summons the designed problem solving web page. Moodle forwards the user's information to the page.

Figure: 4
The Screen of Teacher Module

The problem that was recorded in teacher module is automatically solved by computer with a model using the methods of forward chaining and backward chaining that take an important place in artificial intelligence applications. Forward chaining is the application of inductive approach, towards the result from the data. Backward chaining is the application of deductive approach, directly towards the result. As a result, when the user in teacher module makes a problem input;

- **Problem is recorded to the Question Database.**
- **The values of all variables in the problem are found and the user is asked to select the unknown –the result of the problem-**
- **By the help of backward and forward chaining methods, the result of the problem and the solution ways are determined.**
- **By transforming the result and solution ways to sub-problems step by step, they are recorded to the Sub-problem Database.**
- **In this way, the system makes problems ready to ask the students.**

If the user wants to operate on a problem that was formerly entered into the Question Database, he can make necessary arrangements by summoning the related problem from the database this time and then the system makes the problem ready to ask students by following automatically the steps in problem input when the user confirms the problem.

Student Module

Student Module (Figure: 5) is the module in which the user can watch the lecture of the subject, can access the problem solving system or can have test exam when he logs in.

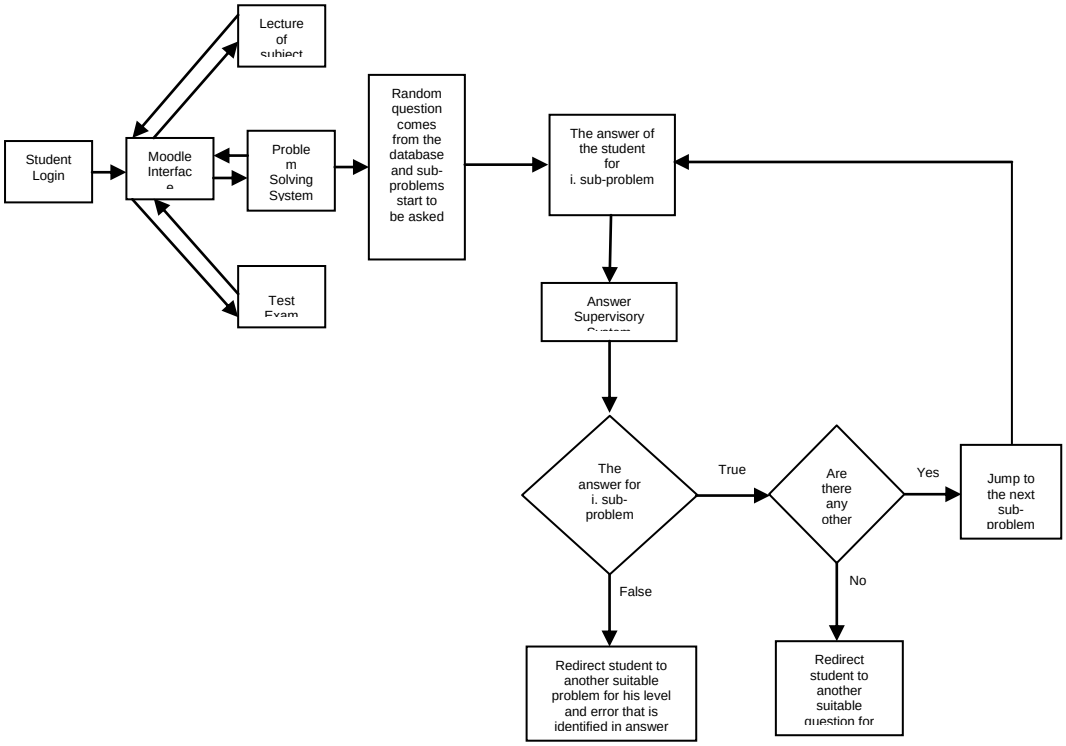

Figure: 5
General Structure of Student Module

Firstly, the user logs in to the system via Moodle interface (Figure: 6).

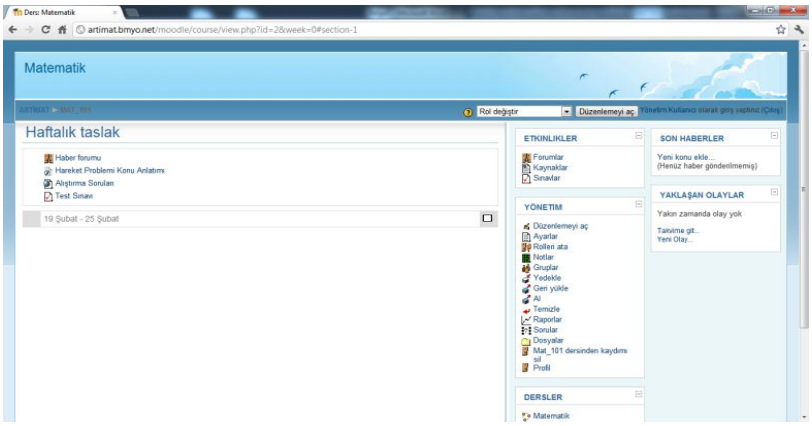

Figure: 6
Student Module Moodle Screen

The user who logs in to the system via Moodle interface summons the page of lecturing, designed problem solving web page or test exam page (Figure: 7). The data of the user who summons the page is forwarded into the page that pops up by Moodle.

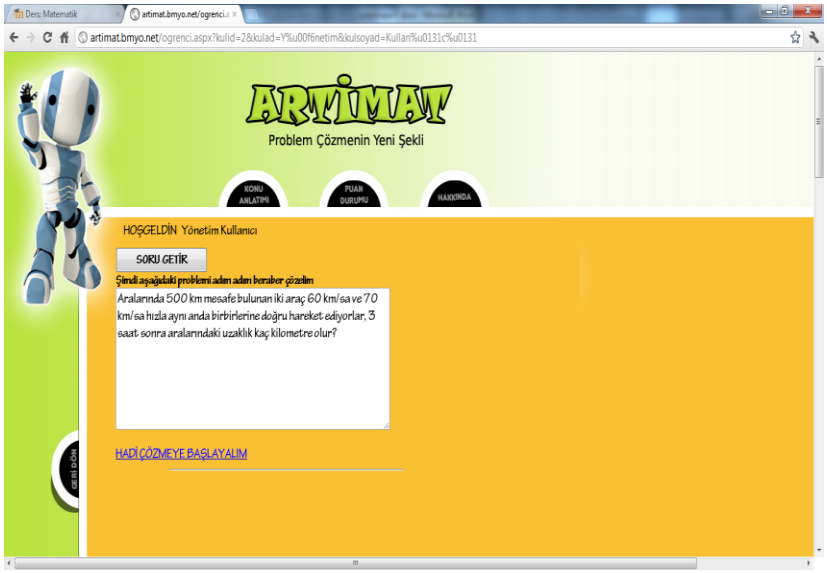

Figure: 7
Problem Solving Screen

The user can use lecturing page, or can enter problem solving system, or can use test exam independently of one another. If the user logs in to Problem Solving System; by starting to work initially with a moderate random question from the pool of questions that are grouped according to the level of difficulty, the system makes routings according to the level of the user.

The system makes this routing by asking sub-problems to the user for every step of the process and compares the answers of the user in each step with its own results. If the user gives correct answer for sub-problem, the system directs the user one at a time to the next step until finding the final result.

If the answer is wrong, it wants the user to give a new answer alerting with a message that is appropriate for his answer. If the user gives wrong answer again, the system asks an easier question after being convinced that the question is too hard for the level of the user. The difficulty level of the questions increases as long as the user correctly knows the final results of the problems and decreases if the user gives wrong answers to them. The user can leave the system at any stage. All the steps of the students in problem solving whether they are right or wrong, time that is spent to solve the problem, access date to the system, the number of problems that they have solved wrong or right and total scores are kept in the system.

Students do not have to necessarily follow the operation steps. Students can try forward steps in the way they want or, they can complete the solution by pressing "I FEEL LUCKY" button entering the answer to the area that is allotted at the beginning of the operation when they find the result or by entering the result at any time after the starting for the solution.

RESEARCH MODEL

Mixed research approach, in which qualitative and quantitative approaches were used together, has been preferred in the research (Cohen & Manion, 2000; Miles & Huberman, 1994). The opinions of both students and teachers have been taken in order to develop the expert system named ARTIMAT in terms of conceptual proficiency and ease of use in the study. However, academic successes of the students in implementation groups have been compared statistically by taking their mathematics examination marks for the first term of the academic year of 2011-2012.

Performing the Implementation

The implementation, which was conducted in order to evaluate the system, has been performed with 4 teachers and 59 students in 10^{th} grade in an Anatolian High School in Trabzon. ARTIMAT system has been implemented for both two groups for three weeks for two hours in each week in computer lab and in a way that each student has used his/her own computer.

Data Collection Tools

The data has been collected from implementation groups in three ways: success grades of mathematics course, teacher interviews and student interviews. Written interview forms have been prepared in order to get students' opinions and thoughts about the system. The questions asked in the interview forms are given below.

- **Which one of the features of the system did/didn't you liked most?**
- **Did the system be helpful for your problem solving process? Can you explain?**
- **Did you like the visual design of the system? What are your thoughts in terms of its being better?**
- **Did the system change your point of view on problem solving? (Positive/negative)**

- **What are the features of system the easiest to use? Can you explain?**
- **Are there any sections that you have had difficulty to use the system? What are they? Can you explain?**
- **What are your opinions and suggestions about the system?**

Teacher module and student module have been introduced to teachers in order to evaluate ARTIMAT system, and they have been provided to use it, and then their opinions have been taken with semi-structured interviews. Questions asked during the interview are as follows:

- **Which one of the features of the system did/didn't you liked most?**
- **Do you think this system can help students develop their problem solving skills?**

- **Can you compare the system with pencil and paper environment in terms of usability during problem solving process?**
- **Do you evaluate the usefulness of the system during transferring the problem (during the writing of the problem) into computer environment?**
- **Did you like the visual design of the system? What are your thoughts in terms of its being better?**
- **Do you think that the system is successful in terms of finding the steps to follow in the solution of the problem?**
- **Do you think that the system may be able to find all possible solution ways?**
- **Do you think that the system can do a complete routing for student during problem solving?**
- **What are your opinions and suggestions about the system?**

Analyzing the Data

T-test has been implemented in order to see the academic successes and statuses according to each other of the students in implementation groups by taking their mathematics examination marks for the first term of the academic year of 2011-2012.

By the help of this way, it has been checked whether their academic successes and gender factors in mathematics course were determinant. Interview data has been made transcript by the researcher. The obtained raw data has been initially transferred to writing in accordance with qualitative research techniques by reading one by one and then, the encodings have been made using expressions for determining the main theme of the opinions that the participant wanted to indicate.

As a result of inferences from the encodings, the opinion, which participants wanted to indicate, has been reduced to a form that could be summarized with a few words and themes have been generated (Miles and Huberman, 1994).

The data has been read at different times by different people for the reliability of the encoder and encoding, it has been detected that it was encoded similarly. Glesne and Peshkin (1992) reported that sharing the studies that were obtained from qualitative researches with people who were experts on qualitative researches and receiving feedback from them would increase the reliability of the research.

Also in this study, excerpts have been made from the opinions of students and teachers in order to increase the inner reliability and the validity of research findings.

FINDINGS

Mathematics Success Status of the Groups

T-test results of the students in groups in the application according to their grades and genders are given in Table: 1 and Table: 2 by taking their mathematics examination marks for the first term of the academic year of 2011-2012.

Table: 1
T-test Results of the Students' Mathematics Exam Marks According to the Classes

	CLASS	N	Mean	Std. Deviation	Std. Error Mean	p
AVERAGES	10-C	30	75,5067	14,35460	2,62078	0,302
	10-A	29	71,5724	14,65291	2,72098	

As can be seen in Table 1, there is no significant difference between the averages of the classes (p>0.01)

Table: 2
T-test Results of the Students' Mathematics Exam Marks According to the Gender

	GENDER	N	Mean	Std. Deviation	Std. Error Mean	p
AVERAGES	FEMALE	47	74,2043	14,50856	2,11629	0,513
	MALE	12	71,1000	14,89539	4,29993	

As can be seen in Table 2 as well, there is no significant difference between the averages of the genders (p>0.01). The results obtained have showed that groups had no differences according to their grades and genders. These findings show that interview data can be assessed without discrimination according to the grades and genders of the students.

Student Interviews

Each student's opinions and thoughts about the system, which they used for 6 hours in total, have been compiled without discriminating grade and gender and, results obtained from these have been given in the basis of interview questions below.

Question: 1
Which one of the features of the system did/didn't you like most?
Features that were liked in students' answers have been determined as;

- **Providing individual learning**
- **Being a more instructive and permanent system in mind**
- **Providing the identification of the problem and knowing in-hands**
- **Solving systematically the question step-by-step with a different method**
- **Trying different solution ways by courtesy of the system**

- **Being easy to use**
- **Visual design**
- **Feature that students can add photos by creating their own profiles**
- **Students' being able to communicate with each other via the system**

Features that were not liked in students' answers have been determined as;

- **Being unable to reach directly to the result**
- **The obligation to follow the steps**
- **Loosing time as there is a different solution way**

Question: 2
Did the system be helpful for your problem solving process? Can you explain?
Students have stated the positive sides of the system as follows;

- **It shows what should be done in the process of the problem solving**
- **It helps students think on the solution of the problem**
- **It increases the knowledge about the solution of the problems**
- **It strengthens the feature of the judgment**
- **It contributes to the understanding of the problem**
- **It makes easier to solve the problem when it is got used to using the system**
- **It warns when the wrong way of solution is selected**
- **It develops the habit of systematic problem solving**
- **Students have stated the negative sides of the system as follows;**
- **It loses time as it prolongs the process of solution**
- **Students are required to do operations, which they do by formula in short way, step by step in the system**
- **They spend much more time for the questions that they will normally solve in less tim**

Question: 3
Did you like the visual design of the system?
What are your thoughts in terms of its being better?
Students have stated in the positive opinions that;

- **The system is useful, can be reached quickly and conveniently and, its design is simple at the same time**
- **System deficiencies that are wanted to be completed by the students are;**
- **System should be enlivened with animations on the subject**
- **Page color should be changed**
- **More colorful mathematical symbols should be used in the system**
- **Warnings for students should be more conspicuous**

Question: 4
Did the system change your point of view on problem solving? (Positive/negative)
Students have stated in their answers that;

- **They can see at which point they have made errors as they have solved the problems step by step**

- **It is provided to understand the question better to do operations, which they normally try to do in mind without writing the data, by writing in the system**

- **Possibility of making a mistake decreases as they progress step by step to solve problems through the system**
- **The system makes students to think over the problem instead of solving problems with formulas by heart**
- **Solving problems step by step provides them to do operations more accurately**
- **Solving problems in the computer environment makes problem solving process more enjoyable**
- **Solving problems in the system provides a better learning although it takes longer**
- **The system is useful for the development of human brain as it provides students the chance to use different solution ways for students in problem solving and, it can differentiate the monotonous types of question solving**

Question: 5
What are the features of system the easiest to use? Can you explain?
The majority of the students have reported that the system is easy to use in general.

In addition, the following answers have come;

- **Given and desired, which are the first phase of the solution of the problem, are written**
- **It is better seen in the table what the given and the desired are**
- **Students can communicate with each other via the system**
- **Problem solving steps can be selected**

Question: 6
Are there any sections that you have had difficulty to use the system?
What are they? Can you explain?
Responses from students focus on certain points. It has great importance for students to use the system easily and efficiently. It is possible with the feedback to develop the system accurately and efficiently.

Although it has been said that the system is generally easy to use according to the responses, the following difficulties have been indicated as follows;

- **Doing operations step by step seems complicated**
- **I find it hard to choose the solution way**
- **I have difficulty in transferring the operations to the computer**
- **I find it hard to place the data**

However, these have been stated by only five students but not in general.

The following question has been asked to the students in the oral interviews with them.

"What is the reason that you have determined as difficulties? Is the system complex or impractical?"

The answers are as follows.

Student 1: "In fact, the system is as easy when it is got used to but pen and paper is much easier for us. How many of us have solved questions via computer up to now? We are pencil and paper youth."

Student 2: "The system could be more useful after a while, but it is unusual. I could not abandon to use pencil and paper."

Student 3: "No. The system is easy to use but pencil and paper is faster, we need to pay more attention on the computer."

Student 4: "The system does not allow us to pass when we write incomplete information. I have to step by step when I want to write the result directly."

Student 5: "The system may initially seem useful, it is unnecessary to do operations step by step in some questions after a while."

Question: 7
What are your opinions and suggestions about the system?
General answers of the students are as follows;

- **The system is successful and interesting. It makes the solution more fun,**
- **The system has been crafted well, funny features relevant to mathematics such as games, jokes and etc. can be added,**
- **The intelligence and skill games and music can be added to take mind off,**
- **It should be developed for other types of problems such as pool, percentage and so on,**
- **Actually, it is a nice system, but we attach importance to the result not to the phase. It will be better if it is result-oriented,**
- **The system is nice, but phases should be facilitated,**
- **The main page of the system can be better,**
- **The system should include direct reaching to the solution**

Teacher Interviews
As a result of interviews of teachers who use the system, the obtained themes are given in Table: 3.

Four teachers who have participated in the interviews are coded as P1, P2, P3 and P4.

Table: 3
Teachers' Opinions on the System

	P1	P2	P3	P4
Advantages of the system	• Allowing to write the given Providing feedback at each stage (True/False) • Useful for beginners	Routing the student Providing feedback	olving the entered question	Giving the opportunity to teacher and student to solve the problem
Disadvantages of the system	• Boring for students in advanced grade	Visualization should be increased Causative feedback should be given	Boring for students in advanced grade	NI
Status of helping the development of the problem solving skills	• It helps	It helps	It helps to lower grade students	It helps
The usefulness of the system during transferring the problem into computer environment	• Useful	Useful	Useful	Useful
Visual design of the system	• It can be better	Visualization can be further increased	It can be better	Classic, more formal
Finding the steps to follow in the solution of the problem	• Successful	Partly successful	Succes sful	Successful
Status of the system to route the students	• Partly successful	Routings are successful	NI	Routings are successful
Suggestions	• NI	NI	Causative feedback should be given	it should be enriched with visuals It should be enriched with different types of questions

NI: No information

In the interviews for the evaluation of the system, teachers state that the system is disadvantageous in some aspects while they find it advantageous in many aspects.

It has been expressed as useful that the given and the desired were asked step by step for the problems in the system, and that feedback was provided as true-false at each stage, that a question, which was entered by teacher, was analyzed and solved by the computer, and that the opportunity to solve different types of questions was given to the students. However, disadvantages of the system have been expressed as that a causative feedback could not be given (information about why it is wrong), that the visualization was weak, and that it might be boring for the students in advanced degrees. The opinions of teachers on these answers have been presented below:

"Requesting the given step by step and providing feedback at each stage is useful for beginner students to this subject... It is initially useful but may be tedious at later stages (P1)."

"It is very useful to route the students and to say that the answer is right or wrong after solving the problem but, I think that visual part in the question should be at the forefront. The system should explain why it is wrong rather than saying that it is right or wrong (P2)."

"In fact, I liked the system... It can be a very useful program. It should be worked on some more. It is program that will help students at each stage even teacher if it becomes a program that can solve much more difficult questions after increasing the degrees of current questions (P4)."

"I like its feature to solve the question. I dislike its feature to be boring for mid-level students. But it is a good system for lower level students who cannot learn (P3)."

When they have been asked to evaluate the usefulness of the system according to pencil and paper environment, two of teachers have stated that pencil and paper environment has been more useful. Other two teachers have stated that this might differ according to the ability of student to use computer. Excerpts for this opinion are as follows.

"We learned that it would not be without pencil and paper. It was recorded to our subconscious like that. But I think it will work on the generations who have grown with the computer. Because, they use the computer like pencil and paper (P4)."

"Pencil and paper environment is handier. It takes time in the computer. For this reason, pencil and paper is more advantageous after learning the work (P1)."

"I think that pencil and paper has an extra sense on human beings. I prefer pencil and paper rather than being on the screen (P3)."

"...it may not produce difficulty for students who use computer well (P2)."

The interface, which was used in transferring the problem into the system, has been found useful by all teachers. Visual design of the system has not been found satisfying by teachers and it has been determined that editing should have been done.

The opinions about the visual design of the system have been expressed as follows:

"Visual quality may be further improved. The main topics may be more noticeable. Each problem may be in a different color and its solution in a different color. (P2)."

"I found it classic. I found it more formal. It may be more colorful. Today's students enjoy more striking, colorful and fun things. It may be supported with shapes (P4)."

"I did not like the visual design, that is, the selection of color. The blue color could have been better. Design is good except color. Headings may be given in different color. The main headings could have been a different color (P3)."

It has been seen that one teacher found the system partly successful in finding the steps to follow in the solution of a problem in the system while three teachers found it successful. The reason, why one teacher found partly successful, has been seen that the system could not resolve a type of question except the types of question that it solved. Guidance of the students by the system has been found successful by teachers. Teachers' opinions on this issue are as follows:

"...I find the system successful in terms of that it allows working individually and sees own mistakes step by step (P4)."

"It is good for the child to solve the question with the guidance of the system. However, it may route the student better to say why he has made mistakes rather than saying that you have made mistake (P1)."

"I think that it has made a good routing. At least, it provides systematically step-by-step solution. In this respect, it is good (P2)."

It has been indicated that visual design should be healed and causative feedback should be given in general when teacher suggestions have been taken for the improvement of the system. Opinions on this issue are presented below.

"... Let it show the solution of the question at the beginning or during the step rather than saying that you have made mistake (P3)."

"Mathematics will be better when it is visually supported. The system should be visualized with shapes (P4)."

CONCLUSION

In this study, the evaluation- of the expert system called ARTIMAT, which was prepared to develop problem solving skills of students, in terms of conceptual proficiency and ease of use with teachers and students' opinions- has been done.By the help of the findings from student interviews, it has been concluded that students used all the features of the system and were satisfied with them, the system contributed to problem solving process in various aspects and, it developed students' points of view for problem solving in positive direction but they experienced time concern due to their habit of going directly to the result as they were exam-oriented.

Although the students were reminded that the time was not a priority and that system was to eliminate the difficulties and shortcomings that they encountered in problem solving, time concern of students could not be eliminated. It has been concluded that the system did not change the students' habits of using pencil and paper, and that they could not give up the habit of using pencil and paper yet although they found the system successful in terms of learning the problem solving. Anyway, the study does not have an aim to eliminate completely the use of pencil and paper that students are familiar since then primary school. The majority of the students have indicated that the system was easy to use in general.

It has been concluded from the findings obtained about the difficulties (which students encountered while using the system) that students were result-oriented and they found it hard to accept a different system as they solved test questions with paper and pencil for the examinations. By the help of findings from teacher opinions, teachers are seen to agree on the opinions that the system will be helpful for the development of problem solving skills of the students.

In addition, some of the teachers have stated opinions on that this system will be more helpful on the lower grade students. By the help of responses, it has been concluded that the system is successful in general but it can be made more useful by doing some revisions in terms of design. In the light of findings and feedback from the students, visual design has been changed, and a more lively and attractive design has been prepared. In the system, a section -where intriguing information, anecdotes and stories in mathematical content and interesting events in the lives of famous mathematicians are described- is being prepared in order to keep students vigilant during problem solving process. Improvements on visual characteristics of the system are still being done.

Acknowledgement: **This research is supported by The Scientific and Technological Research Council of Turkey (TUBITAK).**

BIODATA AND CONTACT ADDRESSES OF AUTHORS

Prof. Dr. Vasif NABIYEV received BSc. and MSc.degrees in the Faculty of Computing and Informatics from St. Petersburg Electrotechnical University in 1985, and a Ph.D. degree in the Department of Computer Science from Moscow Technical University in 1990. He is currently the Chief of the Laboratory of Artificial Intelligence in the Department of Computer Engineering in Karadeniz Technical University. His research interests are in artificial intelligence, biometry, human-computer interaction, natural language processing, operational research. He has published over 70 research papers, and authored three university level textbooks titled "Artificial Intelligence: Problems and Methods" (1st ed. 2003, 2nd ed. 2005, 3th ed. 2010, 4th ed. 2012), "Introduction to Algorithms" (2007, 2009, 2011) and, "Combinatorial Algorithms" (2007, 2009, 2011)

Prof. Dr. Vasif NABIYEV
Karadeniz Technical University,
Computer Engineering Department, Trabzon, TURKEY.
Email: vasif@ktu.edu.tr

Hasan KARAL was born in Trabzon, Turkey, in 1969. He graduated from Karadeniz Technical University, Faculty of Engineering, Department of Electrical and Electronics Engineering in 1990. In 1993, he received his M.S and in 2000 he received his Ph.D. from Karadeniz Technical University, Graduate School of Natural & Applied Sciences, Department of Electrical and Electronics Engineering. He is chair Karadeniz Technical University, Fatih Faculty of Education, Department of Computer and Instructional Technology. He is also manager Karadeniz Technical University Distance Education Center.

Assoc. Prof. Dr. Hasan KARAL
Karadeniz Technical University,
Computer and Instructional Technologies Department, Trabzon, TURKEY.
Email: hasankaral@ktu.edu.tr

Selahattin ARSLAN is an assistant professor in Primary Mathematics Education Department in Karadeniz Technical University, Trabzon, Turkey. He received his PhD degree from the University of Joseph Fourier in Grenoble, France, in 2005. He is interested in ICT, Teacher Education and Mathematics Education, particularly differential equations.

Assoc. Prof. Dr. Selahattin ARSLAN
Karadeniz Technical University,
Primary Mathematics Education Department, Trabzon, TURKEY.
Email: selaharslan@yahoo.fr

Ali Kürsat ERUMIT was born in Samsun, Turkey. He received the B.Sc. and M.Sc. degrees in Computer Education from Gazi University (KTU) in 2003 and 2007, respectively.. He is PhD student at institute of education sciences at KTU now. Currently, he is also a lecturer in the Department of Technical Programming at Besikduzu Vocational School at KTU. His major research interests are in artificial intelligence, distance education, fuzzy logic, and intelligent systems in mathematics education.

Lecturer Ali Kürsat ERUMIT
Karadeniz Technical University,
Beşikdüzü Vocational School, Trabzon, TURKEY.
Email: kerumit@ktu.edu.tr

Ayça CEBI is a research assistant in Distance Education Centre at Karadeniz Technical University. She is currently a Ph. D. student at the Department of Computer Education and Instructional Technologies, Gazi University. Her research interests are in e-learning and fuzzy logic.

Res. Assist. Ayca CEBI
Karadeniz Technical University,
Computer and Instructional Technologies Department,
Trabzon, TURKEY.
Email: aycacebi@ktu.edu.tr

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