

Secondary School Mathematics Teachers' and Students' Views on Computer Assisted Mathematics Instruction in Turkey: Mathematica Example

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ABSTRACT

This study aimed at determining the secondary school mathematics teachers' and students' views on computer-assisted mathematics instruction (CAMI) conducted via Mathematica. Accordingly, three mathematics teachers in Adiyaman and nine 10th-grade students participated in the research. Firstly, the researchers trained the mathematics teachers in the Mathematica program, a computer algebra system (CAS) and CAMI. Then, they provided a suitable environment for teachers to practice CAMI with their students to teach quadratic functions (parabola). Case study, a qualitative research design, was utilized in the study. Semi-structured interview forms were used as data collection tools. The interview data were analyzed using descriptive and content analysis, and the codes and themes related to the topic were obtained. The findings revealed that all the teachers found CAMI implementations interesting as supported by students' views. While all mathematics teachers wanted to benefit from CAMI in mathematics and geometry courses, most of the students asked that CAMI be used in different courses. It was found that students did not have any problems with the Mathematica used with CAMI activities. However, it was also revealed by one student and one teacher that involving CAMI constantly in the courses would hinder preparations for the university entrance exam.

Keywords: *Computer-assisted instruction, computer algebra systems, mathematics instruction.*

INTRODUCTION

Today information and communications technologies have been developing rapidly and new opportunities have been generated for meaningful mathematics instruction. As a result of continuous development of computer technologies, both the quality and the quantity of educational software have been increasing and the alternatives have been growing. (Ministry of National Education [MNE], 2013). According to Baki (2015), "apart from computer being used as an effective computational tool, a more important quality of it is that it can show the abstract mathematical concepts on the screen and concretize them". This concretization will have positive effects on students' meaningful learning. Thus, students' process of constructing mathematical knowledge must be promoted with multi representations and materials and they must be actively engaged in Information and Communications Technologies (ICT). ICT in mathematics instruction is used not with the intent of replacing the teaching of mathematical skills with technology but the purpose is to be able to have all students reach mathematical thinking without paying regard to their skill levels. Students can solve realistic mathematics problems with effective use of ICT and they can spend the time saved from long operations on reasoning and creative thinking (MNE, 2013). Hence it is inevitable that IT in general and computer assisted mathematics instruction (CAMI) in particular will have its place in educational environments.

Computer assisted instruction (CAI) refers to an instruction offered via a computer during the teaching-learning process. In CAI, students interact with the computer and determine their weaknesses and learn from their performance; they are responsible for their learning thanks to the feedback offered, and they are more interested in the lessons via animation, graphs, sound and demonstrations (Baki, 2015). The primary goals to use a computer in mathematics instruction are to activate students' higher order cognitive skills and enable them to create their own mathematics knowledge based on their interaction with mathematics.

Yeşilyurt (2010) conducted meta-analysis by examining 155 studies carried out in science and mathematics education fields using quantitative research methods in Turkey between 2002 and 2008. The study concluded that student academic achievement in the learning environment where CAI was used was higher at a meaningful level when compared to learning environments using the classical method.

CAI can be discussed as a system which is interconnected regarding software, hardware and teacher. Even if a computer with the best hardware features and the best qualified teacher is used, software still plays an important role as an infusive factor. If the goal is to be attained efficiently in CAI, three factors must be paid attention (Arslan, 2003). Of these three factors, the deficiencies with hardware will be eliminated in line with the activities carried out within the context of The Movement to Enhance Opportunities and Improve Technology (FATİH) project initiated by the Ministry of National Education (MNE) and Ministry of Transport in Turkey at the end of 2010. This project aims at equality of opportunity in education, improvement of technology in schools, and effective use of ICT tools in the teaching-learning process.

The Project intends to provide LCD Interactive Boards and the infrastructure of internet network in all schools, and to distribute tablet PCs to every teacher and student. It provides for in-service training for teachers to enhance effective usage of ICT equipment in the classroom teaching-learning, and to form educational e-contents in accordance with ICT-assisted teaching programs (MNE, 2013). When teachers were considered as the second factor, it was emphasized by many studies that teachers were the main factor in benefiting from CAI in learning settings (Hutkemri & Zamri, 2016; Öksüz & Ak, 2009; Seferoğlu, Akbıyık, & Bulut, 2008; Umay, 2004). On the other hand, it was stated that one of the biggest factors preventing CAMI from taking place in the classroom was teachers' weaknesses in this subject (Ersoy, 2005; Hangül & Devrim, 2010; Kutluca & Kici, 2010; Seferoğlu et al., 2008; Yenilmez & Karakuş, 2007). When software, the third component of the process, is considered, again the effect of teachers is viewed. Kuzu and Yavuzalp (2008) conducted a study on 471 primary school teachers in Turkey. Their study concluded that although teaching software existed in the schools with CAI classrooms and educational software was developed in all fields, a considerable number of teachers (26.8%) were unaware of them and they did not examine the software in their fields (27.6%). When considered from this point of view, identifying teachers' real opinions about CAMI transparently will be possible after they are trained about CAMI and given opportunities to implement educational software in their classes. Students' views can be utilized as well as teachers' views in order to bring up CAMI activities and the software treated as an infusive factor to better levels.

According to Hohenwarter and Fuchs (2004), using dynamic geometry and algebra software based on computer in mathematics instruction caused a new understanding to develop. Computer algebra systems (CAS), based on the use of symbolic expressions, and dynamic geometry software (DGS), based on geometric structures, are the two most important ones used among the software which can respond to this new understanding, which can be used to create positive teaching, learning, and classroom settings for supporting mathematics instruction and learning (Hohenwarter & Jones, 2007).

CAS which was developed as software that could do symbolic computations as well as numeric computations for solving mathematical problems was obtained by expanding standardized numerical programming languages such as C, Pascal and Fortran (Aktümen, 2007). It is basically possible to divide numeric computations into two. One of them is floating point method which uses a variety of algorithms and does number based computations. In this method, the results obtained are not precise because the operations are number-based and most of the time computations are done using approximate values. Another computation method is symbolic, or algebraic computation, or computer algebra which is based on doing computation on symbols representing mathematical objects. While the term symbolic refers to expressing an answer in a closed formula or finding a symbolic approximation, the term algebraic means

carrying out computations exactly (Davenport, Siret, & Tournier, 1993; Kabaca, 2006). Besides being an effective symbolic computation tool, another important characteristic of computer algebra systems is their ability to draw graphs at an advanced level and to visualize. Thanks to their developed abilities, CAS can do drawings in Cartesian, polar, and cylindrical coordinates.

Mathematica is one of the most developed CAS of our day and its first version was released in 1988 by Wolfram Research; since then it has been constantly improving with its more than twenty versions published by Wolfram Research. Mathematica is an expandable system which works with input-output logic, has a graphical interface, allows easy entry of graphs and gives opportunities to carry out operations on chart objects (Gülcü, 2004). Another feature of Mathematica is its Computable Document Format (CDF), an electronic document format designed to allow easy authoring of any content generated on Mathematica without having to set up a program on a computer. Thanks to the CDF player which can be downloaded free, the structures developed by the programmer can be examined and they can be manipulated within the allowed limits. Moreover, Mathematica has structures such as a slider allowing users to manipulate any mathematical and geometrical structures and this is an important feature of Mathematica which intersects with DGS.

It was revealed in the studies on the activities of computer-assisted mathematics instruction conducted through CAS that students' conceptual understanding levels (Aksoy, 2007; Ghosh, 2003; Kabaca, 2006; Sevimli, 2013; Sevimli & Delice, 2015), problem solving skills (Aktümen, 2007; Sevimli, 2013; Tuluk, 2007), academic achievement (Aksoy, 2007; Bulut, 2009) and attitudes toward mathematics (Aksoy, 2007; Aktümen, 2007; Kabaca, 2006; Tuluk, 2007) were higher at a meaningful level when compared to students in control groups.

In the international literature review on teaching activities carried out via CAS, similar results were obtained as well. These results can be listed in the way that students learn maths better and with a deeper comprehension via CAS, that CAS encourage students' independent learning and success, and thus increased their motivation for mathematics, that CAS enable students to deal with more difficult and realistic mathematical structures more easily in earlier periods, and that CAS can meet workplace requirements in the 21st century (Buteau, Marshall, Jarvis & Lavicza, 2010; Lavicza, 2008; Marshall, Buteau, Jarvis, & Lavicza, 2012).

Tatar, Kağızmanlı, and Akkaya (2013) conducted a study examining 126 studies on technology assisted mathematics instruction in Turkey which were published between 2000 and 2011 in terms of demographic information, key words, and methodology. Results of their study emphasized that the sampling of the most of the studies carried out in Turkey consisted of undergraduate students, and the secondary school students participated only in 11% of the studies. Similarly, in the articles examined it was found that only 8% of the research studies included secondary school students and secondary school mathematics teachers as participants, which is quite low. The key words used by the researchers in the articles were also examined; these examinations revealed that the studies published in Turkey did not include mathematics topics adequately and the research studies about the software which could be used in mathematics education were limited. On the other hand, DGS was encountered more than CAS (about 50%) among the key words and Mathematica program was not mentioned.

The literature review shows that studies on using CAS as a teaching-learning tool in Turkey are quite rare (Tatar et al., 2013), and those researches, as in the international literature, have been carried out on general mathematics (Calculus) with undergraduate participants (Buteau et al., 2010; Lavicza, 2008; Marshall et al., 2012). On the other hand, it is also seen in researches on secondary school level that CAS-based graphic calculators have been used mainly (Baki & Çelik, 2005; Pierce, Ball, & Stacey, 2009), and that computer-based applications have not been dealt with sufficiently (Pierce et al., 2009). This present study, involving secondary school mathematics teachers and students as participants, is an attempt to contribute to literature with its focus on the effects of using CAS in the teaching-learning environment.

Aim of the Study

The purpose of this research study is to determine the views of secondary school mathematics teachers and students, who have not had any experience about CAS and CAMI before, about CAMI activities

which have been carried out via “Mathematica 9.0” program that they have just used for the first time. In order to examine mathematics teachers’ and students’ views about this new situation, the following was selected as the research question of the study: “What are the views of secondary school mathematics teachers and students who practiced CAMI activities via Mathematica program for the first time?”

METHOD

For the sake of revealing the present situation in the research, a detailed and in-depth perspective, without any generalization concerns, was adopted. Thus, the research study was carried out using the case study method, one of the qualitative research methods. A case study is a design that investigates a phenomenon within its real life context, discusses “how” and “why” questions in the event that the researcher has very little control over the phenomenon (Yin, 2014), and involves in-depth and detailed examination of a single case or multiple cases, settings, or other systems connected with each other (McMillan, 2000).

At the beginning of the research three secondary school mathematics teachers were given a 16-hour training on the fundamentals of CAMI, the use of Mathematica program which is a CAS, and CAMI implementation examples. Then, mathematics teachers in their suitable time taught secondary school 10th grade students graphing quadratic functions (parabola) benefiting from Mathematica program in the computer laboratories in Adiyaman University (Figure 1). The aforementioned activities lasted for five lesson hours sticking to the lesson plans prepared by the teachers themselves and curriculum. Nine CAMI activities were utilized in this process.



Figure 1. A visual on the physical conditions of computer laboratories where the teachers practised.

CAMI activities were designed by the researchers with the worksheets considering student gains about the topic parabola and asking opinions of eleven mathematics teachers and three mathematics educators. Moreover, during the process of preparing CAMI activities, Wolfram Demonstrations Project (2014) activities developed by the Wolfram company, a producer of Mathematica program allowing free access, were used (Figure 2).

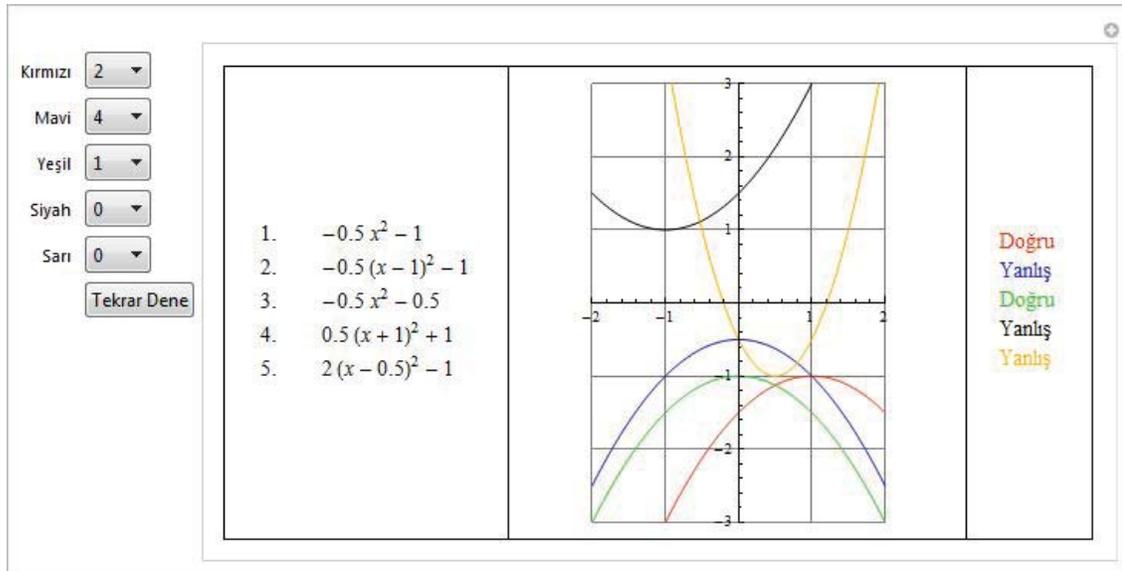


Figure 2. Screenshot belonging to one of the activities.

After the mathematics teachers carried out CAMI implementations via CAS, interviews were performed with them and their three students.

Participants

The research was carried out with three mathematics teachers working in different high schools in Adıyaman city center, located in the Southeastern Anatolia Region, and 63 secondary school 10th grade students in the 2013-2014 academic year. Convenience sampling technique was used to select teachers. According to Yıldırım and Şimşek (2008), convenience samples are relatively less costly and they are practical and easy for some researchers. Convenience sampling is to select a population due to its convenient accessibility and proximity. Random sampling was used for selecting nine students whose opinions were asked. The researchers randomly chose three students from each class where the CAMI implementations were carried out.

While two mathematics teachers who participated in the study had between 10 and 15 years of teaching experience, one of the teachers had more than 20 years of teaching experience. None of the teachers received training about CAMI during their college years or teaching profession before. Three teachers had undergone training on using interactive board within the context of the FATİH project.

Data Collection and Data Analysis

Semi-structured interview forms were used to identify the secondary school mathematics teachers and students' views. While creating the semi-structured interview form, firstly the literature about CAI and technology integration in teaching-learning environments was reviewed (Demir, 2011; Demir & Özmantar, 2013; Leonard, 2001; Taşlıbeyaz, 2010) and preliminary drafts were prepared by utilizing resources containing information on scientific research methods (McMillan & Schumacher, 2001; Yıldırım & Şimşek, 2008; Yin, 2014). Later, opinions of four mathematics instruction experts on the preliminary drafts were taken and drafts of semi-structured interview forms were created. A pilot implementation was then made to ensure validity of the mentioned draft forms and eliminate their shortcomings if any. In the pilot implementation, the draft forms were given to 11 mathematics teachers who utilized ICTs in their classes, as well as their students. The necessary modifications were made on the drafts based on the findings obtained, and the opinions of a mathematics educator and three mathematics teachers. These modifications were generally about re-ordering questions and making questions clear and comprehensible. Additionally, the final question "Is there any other opinion or recommendation you want to state regarding this issue?" was added as the last question to the draft form used in pilot interviews with students. The final version of the semi-structured interview form was therefore created.

All of the interviews were carried out one-to-one with the participants, and their voices were recorded with their permission. Those voice recordings were transcribed and analyzed through descriptive and content analysis. Data were primarily summarized and interpreted using descriptive analysis. Then, content analysis was utilized to determine the concepts and themes which were not noticed through the former analysis. The data were examined carefully during the content analysis process, and then codes and themes were identified with a holistic view. The codes obtained were presented in tables with their frequency values under the themes related to them. To assure objectivity of the study, the views of some teachers and students who helped to create the codes were cited. Then, the codes and themes were checked by the three mathematics teachers and the necessary corrections were made. The teachers were called T1, T2 and T3 while citing the data and quotations. The students of each teacher, whose opinions were taken, were given pseudonyms such as S1.2 (the second student of Teacher Number 1) and S2.3 (the third student of Teacher Number 2).

In order to achieve internal reliability and validity in the study, the collected and analyzed data were ensured consistent both internally and in terms of the theoretical framework. In this process, the researchers performed their investigations by taking into consideration how the study would be understood by an outsider. To achieve external validity and verifiability of the study, the raw data obtained during the study and the conclusions reached were analyzed comparatively, and subjected to expert analysis later. The findings and conclusions in the study were finalized after reaching agreement with relevant experts. Moreover, all the data collection tools, obtained data and field notes used in the study were stored on electronic media for re-usage in cases where necessary.

Findings and Results

The findings obtained in the research were presented under two sections as teachers' views and students' views.

Teachers' Views

In this section, the findings obtained from the interviews carried out with high school mathematics teachers who implemented CAMI via Mathematica program, a CAS, were presented.

An ideal classroom environment to carry out CAMI.

The teachers who benefited from CAMI in their lessons were asked the following questions: "In your opinion, what must be the ideal classroom environment to teach mathematics and geometry courses with CAMI? What kind of materials and equipment are needed in the classroom?" Their responses to these questions were examined under the category of "Ideal classroom environment to carry out CAMI" and the codes obtained were presented in Table 1.

Table 1 An Ideal Classroom Environment for Implementing CAMI

Code	f
Every student must have a computer/ tablet	3
There must be interactive boards compatible with their tablets	3
There must be suitable educational software	3
There must be a white board	1

T2 who stated that every student was required to have a computer/ tablet and also an interactive board or a reflector like a projector and a white board was needed opined the following:

First of all, every student should be provided with a computer. As students themselves will follow from them and also they will practise it, one computer per student must be provided. In addition, a projector or an interactive board and a white board can be useful.

T3 who thought that students must have a computer / tablet and added that the smart boards in the classroom environment must be compatible with this computer/tablet and also they must interact with each other shared his views on the issue and on available technological equipment:

“Students must have a computer or a tablet. If the tablets interact with the teacher’s whiteboard, they will be more efficient. ...[Tablet computers] have not reached the students yet. I have one. Even if we have them, we are unable to download every program on it. We have some problems. Right now, I cannot use the tablet effectively. Compatibility problem, I mean, I cannot use the interactive board format with them as it does not allow it.”

T1 emphasized that in addition to equipment in an ideal classroom environment where CAMI would be carried out, there must be suitable software:

“...Most importantly, software is required. Well, a program is needed. We used Mathematica but training on how to use it must be given. It must be translated into Turkish and it must be easily accessible. I mean it can be used, other software programs can be used but in addition to equipment which a student can carry out and obtain a result easily, there must be software.”

When the mathematics teachers who benefited from CAMI in their lessons were asked the following question “Is the current condition of your school suitable for the implementation of CAMI?”, all of the teachers’ (three teachers) responses were negative. It was revealed during the investigation that only one of the schools had a computer laboratory and none of them had distributed tablets to their students. The following statement of T1 who said that the school where he worked had a computer laboratory but some computer programs did not work because the computers were very old exemplifies this situation:

“Well, it is not possible to say that [current condition for CAMI] is suitable. There are smart boards and interactive boards in our classrooms but our computer laboratory is not suitable in terms of infrastructure. The computers are very old. We cannot download new programs. They need to be updated. I mean, our school needs to be renovated and modernized technologically.”

Positive sides of the courses taught by the mathematics teachers via CAMI.

When we asked the teachers who implemented CAMI in their classrooms whether there was a difference between the courses (taught with traditional/classical method) and the courses taught with CAMI, three of the teachers remarked that there were differences between them.

Then, we asked the teachers “What are the positive sides of the CAMI activities you did, what did you like about them? Can you please explain them?” and their responses to these questions were categorized under the title of “Positive effects of CAMI implementations by the teachers” and presented in Table 2.

Table 2 Positive Effects of CAMI Implementations by Teachers

Code	f
Interesting for students	3
Reducing teachers’ course load	3
Enabling students to learn by discovery	2
Materializing learning at a higher level	1
Actualizing more concrete explanations	1
Increasing student participation in the course	1
Actualizing student-centred learning	1
Giving immediate feedback to the students	1

T1 who thought that due to students’ interest in computer, CAMI drew their attention and at the same time the students learned by discovery in the courses taught by CAMI and these enabled students to undergo learning at a much higher level when compared to classical teaching method shared his opinions:

“Computer is a new application which attracts more attention. A child approaches it as a game and thus it brings more benefits. Popularizing it will certainly bring more benefits.”

“For example, we taught parabola. When we teach it with classical method, we draw a figure on the board, children try to comprehend what they see on the board but a child discovers various alternatives on the computer screen by applying on his own. And I saw that there were big but positive differences between the understanding, comprehension, and comprehension level of the students who were taught with classical method and the understanding and comprehension level of the students who performed operations on the computer by themselves. I mean a student who determines the coordinate of a vertex on a computer can say it more easily but we make the other student memorize it. In other words, while one of them discovers, the other one memorizes it. This means a much bigger difference in education.”

The following opinions belong to T2 who stated that CAMI provided a student-centered learning environment which increased student participation in the course and also reduced teachers' course load:

“As teachers, we are the presenters; we transmit information to the students. Unfortunately it is both boring and tiring for a person. We only guide or facilitate the student who has a question in computer assisted mathematics instruction. When a student gets stuck on a question, we help him. Everyone participates actively in the course. Therefore, the lesson is not very tiring. The course becomes more fun.”

Besides these opinions, T2 who stated that student participation in the course increased with CAMI implementations and thanks to the immediate feedback students received from the computer, they saw their mistakes and made comments on them support his views with the following statements:

“[Students] are engaged actively in the course. They enter numbers, draw graphs, do different things. Well, the students are involved in it so they are more instructive. At least they see their mistakes directly via computer. If he enters a wrong data and a different result appears, he tries to interpret why it came out like that.”

The following opinions belong to T3 who said that mathematical concepts would be transmitted to the students more concretely via CAMI:

“Students see things more concretely. We solve directly on the board as we want, draw a graph, we say this is the point. By saying this is $f(5)$, we write it here but it comes out by itself, we explain it much better to the students. Students understand much better.”

Negative sides of the courses taught by the mathematics teachers via CAMI.

We asked the teachers “What are the negative sides of the CAMI activities you did, what you did not like about them? If there are, can you please explain them?” and their responses to this question were categorized and discussed under the title of “Negative sides of CAMI implementations revealed by the teachers” (Table 3).

Table 3 Negative Sides of CAMI Implementations Revealed by Teachers

Code	f
Difficulty of controlling what students are interested in on a computer during the course	1
Students not revising their lessons	1
Students not being able to improve their operational ability	1

Teachers' requirement to develop documents and materials	1
Hindering preparations for university entrance exam	1

T3 thought that he had troubles controlling what students were interested in on the computer during the courses carried out with CAMI and said they would have problems about revising their lessons after the school because students did not take notes in the traditional sense. He expressed his opinions in this excerpt:

"I sometimes cannot control what students are doing on the computer. For example, when I see them writing in their notebook, I am relieved. They will write, they will revise, they will look at their notebook. Of course if they have tablets, this problem will also be eliminated. But while I am moving around the classroom, I am suspicious of whether they are doing it or not. This is the only negative thing. It depends on a student. What I mean is that if a student wants to cheat, he can cheat while taking notes or writing in his notebook."

T1 is worried that due to CAMI implementations, their operational ability will weaken or will not improve and expresses his worries like that:

"In computer assisted instruction, the only issue that concerns me is that a child will have the computer perform the operations and push his operational ability into the background."

T2 stated that teachers must design materials and hardware in order to actualize CAMI implementations, and at the same time he expressed his views that the course hours must be increased in order to carry out CAMI activities and preparations for the university entrance exam collectively:

"Because our current examination system is used to solving questions and finding the options of the questions, we may need more time in this system. I mean because we can comprehend the topic much better here."

"Time can be a problem. Second, a teacher must study his course very well. I mean, he must prepare good materials and documents so that there is no disconnection during the lesson flow. A teacher must have a command of the course, do practices, and get prepared."

Difficulties the teachers encountered during implementations of CAMI activities.

We asked the teachers, "Did you or your students encounter any difficulties while using the program during the implementations of CAMI which was carried out via Mathematica program, a CAS? If you did, could you please explain them?", and their responses to this question were categorized under the title of "Difficulties encountered during the process of CAMI" and the codes obtained were given in Table 4.

Table 4 Difficulties Encountered During the Process of CAMI

Code	f
I have not had any difficulties.	2
Because Mathematica program was in English	1
My students did not have any problems	3

T1 stated that because the Mathematica program used during the CAMI activities was in English, he had problems developing the materials to use in the course and he expresses his views in these words:

"The biggest challenge is language. If they are translated into Turkish, if we have such an opportunity, its use will be easier and bring a lot of benefits.... Whenever I sit at a computer, I wish I knew a little English."

On the other hand, T1 answered the question "In your opinion, did your students encounter any difficulties while using the program during the implementations of CAMI which was carried out via Mathematica program?" like this:

“I don’t think so because I have not received such feedback. I did not encounter such questions asked by my students as why it happened like that because they draw a conclusion by trying and practising on their own.”

Student Views

In this section, nine secondary school 10th grade students’ views on CAMI implementations about parabola were given.

Students’ general views on the courses carried out with CAMI.

During the interviews carried out with some students taught with CAMI, we asked them, “What do you think about the implementations carried out with CAMI?” and as a response, nine students expressed their positive views and admiration about the implementations of CAMI. They were also asked, “In your opinion, are there any differences between the mathematics course taught with CAMI and the previous courses?” and when their responses were examined, similar to the teachers’ view, all of the students stated that there were positive differences in favor of CAMI.

S1.2 stated his positive views about implementing CAMI:

“In my opinion computer assisted mathematics is a very good implementation, particularly it causes us to understand the mathematics course much better because when we learn here via computer, we learn it practically and because we see it, it is much better.”

On the other hand, after comparing classical teaching method with CAMI; S1.2 used the following expressions in favor of CAMI:

“There is a big difference between them. To me, in this course [CAMI] is much better. It is better because it is visual. Because we understand by seeing it, there is a much big difference. I think that I understand much better than other topics. To me, it is really good.”

Positive sides of CAMI revealed by the students.

We asked students, “What do you like about CAMI implementations? If there are, can you explain them?”, and their responses to this question were categorized under “Positive sides of CAMI implementations revealed by the students” as presented in Table 5.

Table 5 Positive Sides of CAMI Implementation Revealed by Students

Code	f
The courses taught with CAMI are fun and interesting	8
It visualizes mathematical concepts	7
It uses time more efficiently	5
It enables learning by discovery	4
It makes me learn much more quickly /easily	3
It makes me focus on the course much better	3
It provides more retention	2
It gives immediate feedback	2
It enables me to learn much better	2
It reduces students’ workload	2
It reduces teachers’ workload	2
It deals with real life problems	1

S1.3 stated that thanks to the lessons taught with CAMI, he overcame the prejudice against the parabola topic and the lesson was fun, and his views are as follows:

“When parabola was mentioned, I opened the book and looked at it. I said to myself, “I cannot understand anything from it”, it seems very difficult and I had a

prejudice against it. But when we learned it in the laboratory, it was quite enjoyable and fun.”

S3.1 remarked that because of the visualization ability of CAMI, he understood the topics much better and he visualized the mathematical structures in his mind. In addition, S3.1 added that as he had to write less in the lesson, he saved time, and he understood it much more easily because he learned the topic by discovery, and thus it facilitated teachers’ work:

“Instead of taking notes during the lesson, we not only save time but also understand it much better due to visualizing them in our mind. Sir, the activities are better, what I mean is they are intended for discovery. To me, it is a good program because learning is easier and also the teacher explains it more easily.”

S2.2 said that he could immediately understand whether he did it correctly or wrongly as computers give immediate feedback on the operations carried out during the CAMI activities, which enabled the course hour to be used efficiently:

“When we enter the numbers on the computer, it lets us see the given distance directly, the roots of that parabola, and all of them. If we solve it, it gives feedback in seconds whether we did it correctly or not. It does not allow us to lose time, it rather enables us to gain time.”

S2.3 stated that the visuals of CAMI activities made contributions to knowledge retention and that both teachers and students got less tired during the lesson due to actualizing learning by discovery:

“It appeals to visual intelligence so it becomes permanent. Neither you nor your teacher gets tired and you discover things like that. You know, you play with $f(x) = ax^2 + bx + c$ and you change the values of a and then you see that the arms of parabola change directions. You learn to discover. I like it very much.”

Ö3.3 who said that he could maintain his concentration for a long time in the lessons taught with CAMI when compared to the lessons taught with classical method explained his views as such:

“To speak for myself, normally in mathematics courses I could understand the course in the first ten or fifteen minutes. Then, I was miles away. But we studied nearly two and a half hour on the computer and my concentration was not broken.”

S3.2 stated that the activity (4th activity) included in CAMI activities about an owner of a farm who wanted to enclose his garden with a fence was a real-life problem and it promoted his interest in the course:

“...for example, I was not interested, well, I was a little interested but that farm question was the question that drew my attention because the things from real life made me think. For example, whenever I see a fence, that question will come to my mind and I will think about that parabola.”

Negative sides of CAMI implementations revealed by the students.

During the interviews conducted after the CAMI implementations with the students, they were asked, “Were there any sides of CAMI implementations which you did not like? If there are, can you explain it?” and the students’ responses were evaluated under the category of “Negative sides of CAMI implementations revealed by the students” (Table 6).

Table 6 Negative Sides of CAMI Implementations Revealed by Students

Code	f
It did not have any negative sides	5
Students did extracurricular activities on computers	2
I had difficulty with the 4th activity	1
I had difficulty with the 8th and 9th activities	1
Looking at the computer screen for a long time tired my eyes	1

It did not include questions and answers for university entrance exam.

1

S1.3 stated that the CAMI implementations carried out in the classrooms did not pose any problem or trouble for him:

“It did not cause any problems to me. It was quite a nice implementation. At least we learned what we did and how we did it. For example, if it is told in a book, we see it only as a picture. But we practised it there and experienced it. In my opinion, it was quite good.”

S2.3 stated that he had difficulty in comprehending the 8th activity which required the identification of rules of quadratic functions whose graph was given on an analytical plane presented as a game to them and the 9th activity which asked them to draw a parabola passing through three points given on an analytical plane, and also added that he tended toward extracurricular activities on a computer:

“I just had difficulty with the games part; I learned what it asked quite late. There were not any other things. And also because we spent plenty of time on the computer, we discovered other fields of interest, I tried to look for the parabola graphs.”

S1.1 had difficulty in understanding the 4th activity (The Farm question) implemented throughout the CAMI:

“In calculating areas, there was a rectangular, that farm question. I had difficulty in understanding how the field got bigger and what it depended on or what it did not depend on. It was a little negative in this aspect. That’s all. But it was much better in other ways.”

S3.3 said that because he had to wear glasses, he could not look at the computer screen for a long time and thus his eyes got tired:

“Because I wear glasses, my eyes extremely hurt when I look at the computer screen for a long time. That is the only reason; I did not have any other problems.”

S2.1 said that more problems needed to be solved in the lesson so that CAMI implementations cannot hinder preparations for the university entrance exam:

“Since the examination system is based on directly solving questions, [CAMI] could be as an example, as an addition. When we look at the examination system, there are a lot of question types about that topic after all. You do not understand them unless you practise them with examples.”

Difficulties encountered by the students while using CAS.

We asked students the question about Mathematica program, a CAS, “Have you encountered any problems in using the program with the activities performed with Mathematica program, a CAS? If so, can you explain it?” and their responses were discussed under the category of “Difficulties encountered by the students while using CAS” (Table 7).

Table 7 Difficulties Encountered by the Students While Using CAS

Code	f
I have not had any problems	9
My peers have not had any problems	8
One of my peer’s activity started late	1

S3.1 stated that he did not have any problems in using the Mathematica program:

“To me, there was not a difficulty because every single thing was considered like sliders, manual data entry, everything shows up when we transfer them. There was no difficulty. As it also guided us from the sheets, there was no trouble, sir. Well,

everyone could do it.”

When the students interviewed were asked whether their peers encountered any problems or not, most of them (seven people) stated that their peers did not encounter any difficulties. However, S3.3 said that the program which one of his peers was going to use for the 2nd activity started late:

“I had a friend who was sitting at the back row behind me and his second program started a little bit late but there were not any other problems.”

Students’ views about benefits of CAMI in mathematics and geometry courses.

In the interviews conducted after CAMI implementations with the students, they were asked, “Would you like to use CAMI method not only for quadratic functions (parabola) but also for the other topics of mathematics and geometry?”, and their responses were discussed under the category of “Students’ views about benefits of CAMI in other courses” with the codes presented in Table 8.

Table 8 Students’ Views About Benefits of CAMI in Other courses

Code	f
I would like to learn mathematics and geometry courses with CAMI	9
I would like CAMI to be used in other courses	6

S1.2 answered the question which asked about the use of CAMI for other mathematics and geometry courses so:

“I also considered that, if implementation is carried out not only for one topic but also for other topics, it will be much better because we see better, and we understand better.”

The following conversation took place between the researcher and S1.1, one of the interviewees, about utilizing CAMI in mathematics and geometry courses:

“S1.1: In my opinion, it will be reasonable to use it. At least, if we skim through once at home, it becomes once; if we go to school and observe it on a computer, it becomes twice; and if we revise it, it becomes three times... For example, it is also important with geometry. To see in geometry, you have to see it to solve questions in geometry. That’s why it is very reasonable. For example, with the topics related to angles ... Computer assisted instruction can also be used with other courses.”

“Researcher: Which lessons do you mean by other courses? Can you give examples?”

“S1.1: Numerical courses. Physics is a really challenging course for me. It is the problem of all students taking numerical courses. Before learning the topic in physics, you can revise once at home and you can understand it. But, if you study it on a computer, if they teach you on computer to show what’s what, it will be reinforced more and you can solve questions better.”

CONCLUSION

When the findings obtained from mathematics teachers who carried out CAMI activities with the help of Mathematica program in their courses are examined, their positive views generally stand out. All of the teachers found CAMI implementations interesting with regard to their students. At the same time they thought that it reduced their course load. Similarly, two teachers considered that CAMI activities enabled students to learn by discovery. It can be concluded from these data that CAMI was perceived as a student-centered and activity-based teaching method. Mathematics teachers’ views about the ideal classroom environment where CAMI will be implemented seem to support this result.

All teachers emphasized that suitable software and hardware like Mathematica in the classrooms

where CAMI would be implemented would be required and also stated that every student in the class must have a computer or tablet. It can be deduced from these findings that teachers did not consider CAMI only as a presentation method but they also regarded it as a student-centered method. These results support the findings of studies where teachers' views on computer-assisted mathematics instruction conducted via Mathematica were explored (Ardıç & İşleyen, 2015; Pierce et al., 2009). These teachers' positive views support the studies of Kaleli Yılmaz and Güven (2011) which introduced primary school mathematics teachers to Cabri, Graphic analysis, Derive, and GeoGebra programs in an in-service training program; the teachers in their study mentioned their positive views about CAMI after their classroom implementations. The current study results share similarities with the findings of studies examining the views of both mathematics teachers (Buteau et al., 2010; Lavicza, 2008; Lavicza & Papp Varga, 2010; Marshall et al., 2012) and prospective teachers (Tatar, Zengin, & Kağızmanlı, 2013) on the use of CAS and DGS in mathematics instruction.

While all of the mathematics teachers stated that the students did not have any problems during the CAMI activities carried out with CAS, one of the teachers said that he had a problem with the language of the Mathematica program. Similarly, Ersoy and Akbulut (2014) conducted a study with pre-service teachers and the results of the study in which CAS was used in the learning environment emphasized the foreign language problem. On the other hand, there are some negative sides of CAMI indicated by the teachers. The main reason could be that current university entrance exam is measuring students' operational skills mostly. While one of the teachers said that students' operational skills would not develop due to using CAMI continuously in mathematics courses, the other teacher emphasized that it would hinder university entrance exam preparations. This result shows parallelism with some results of the study of Çakıroğlu, Güven, and Akkan (2008) who examined mathematics teachers' beliefs about using computers in courses.

When the views of students participating in mathematics course in an environment where CAMI was used for the first time were investigated, it was understood that all of them had positive views about this condition. This was supported by the fact that all of them wanted the CAMI method to be used in mathematics and geometry courses while six of them also wanted it to be used in other courses. While most of the students (seven people) mentioned that they liked CAMI owing to its ability to enable visualization of mathematical concepts, nearly all of the students (eight people) stated that they found the lessons taught with CAMI more enjoyable and more interesting. In addition, some of the students' views on using time more efficiently in the courses taught with CAMI (five people), learning some topics by discovery (four people), and learning more easily (three people) are some of the findings that stand out in the research. Students' positive views about CAMI support the results of research studies in which both DGS was used with the participation of secondary school students (Kutluca & Zengin, 2011; Reis & Özdemir, 2010) and CAS was used (Ardıç & İşleyen, 2015; Taşlıbeyaz, 2010). Similar results were obtained in studies using CAS as a teaching tool and most observed positive developments in undergraduate students' attitudes (Aksoy, 2007; Aktümen, 2007; Aktümen & Kaçar, 2008; Çıldır, 2012; Kabaca, 2006; Kutzler, 2000; Tuluk, 2007; Vlachos & Kehagias, 2000).

When the findings obtained from the students were examined, as stated by their teachers, it was understood that students had no difficulties in using Mathematica, which is a CAS program. Once again, most of the students (five people) stated that there were no negative sides of implementing CAMI in mathematics courses. Two students, however, expressed that they did extra-curricular activities on the computers during CAMI, and one student said that enough problems were not solved for university entrance exam during this process. Considering the emphasis paid by the teachers on similar topics, this condition becomes prominent as factors practitioners must consider. It is clear as demonstrated by various studies (Hutkemri & Zamri, 2016; Öksüz & Ak, 2009; Seferoğlu, et al., 2008; Umay, 2004) that if mathematics teachers who are seen as fundamental actors in CAMI usage in classrooms receive the necessary in-service training, teaching activities utilizing CAS may be conducted successfully. The implementations were found interesting by students and teachers; they did not experience difficulties in using CASs like Mathematica in this process.

RECOMMENDATIONS

CAMI consists of three main components: software, hardware, and teacher (Arslan, 2003). Within the scope of the FATİH project in Turkey, it is predicted that lack of ICT in the classrooms will be overcome in the upcoming process. It is clear that there will only remain equipping teachers with CAMI knowledge and

developing or supplying software with suitable content. In this process, it is vital that teachers should be given in-service teacher training in CAMI. Accordingly, teachers can be trained in CAS software such as Mathematica. Moreover, in the forthcoming process, with the cooperation of education experts and computer programmers, educational materials and e-contents in Turkish which will work on both tablets and interactive boards without any problem can be designed and developed. Current curriculum and textbooks can be re-designed to provide opportunities for actualization of CAMI. The research studies with teachers as participants may continue and the failing points or positive conditions can be determined. Moreover, thanks to such studies, teachers and students' awareness about CAMI can be raised.

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