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High School Mathematics Teachers' Levels of Achieving Technology Integration and In-class Reflections: The Case of Mathematica

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Abstract The purpose of this study is to determine the levels of high school mathematics teachers in achieving mathematics instruction via computer algebra systems and the reflections of these practices in the classroom. Three high school mathematics teachers employed at different types of school participated in the study. In the beginning of this qualitative analysis, the researchers provided the teachers with in-service training titled Computer-assisted Mathematics Instruction Workshop regarding the integration of the Mathematica software which is a computer algebra system in learning-teaching environments. The participating teachers then conducted computer-assisted mathematics instruction activities in their classroom via the Mathematica software regarding the graphs of quadratic equations (parabola). Semi-structured interview and observation forms were used as data collection tools in the study. The data were analyzed using the descriptive analysis method. As a result of evaluation, it was found that before the Computer-Assisted Mathematics Instruction Workshop, the participants either never implemented technology integration or implemented it on the elementary level which is replacement. After the workshop, it was observed that the teachers achieved the technology integration in classroom implementations on the level of transformation and the top level of amplification and showed improvements in this matter. In the observations made after the workshop, it was seen that the teachers generally employed a student-oriented education approach and encouraged students to facilitate their own learning and make their own inferences utilizing computers and worksheets. It was observed that this situation led to changes in classroom routines and contributed to students’ acquisition of deeper comprehension by their own efforts. Additionally, it was understood that the students or the teachers did not have any difficulty in using the computer-assisted mathematics instruction materials prepared in Mathematica.

Keywords Computer-assisted Instruction, Computer Algebra Systems, Mathematics Instruction, Teacher's View

1. Introduction

Today, rapidly developing technology and ever-increasing knowledge, instead of teaching the knowledge directly, bring into question of the necessity for raising a generation who knows how and what to learn and also is aware of how to get the right information from the shortest path (Umay, 2004). As a result of the progress in computer technology, the usage of new and advanced technologies has become compulsory in education and has begun to emerge as a system that plays a positive role in students' learning (Gülcü & Alan, 2003). In this regard, it can be assumed that the integration of information and communication technologies (ICT) into teaching programs will enable computer-assisted instruction (CAI) to become a part of our education system.

CAI is the utilization from computers in educational process so that a student can determine his/her inadequacies, define his/her performance by interacting with the computer and take his / her learning under control by receiving feedbacks and also be more interested in his/her courses with the help of graphics, sounds, animations and shapes created through computers (Baki, 2006). Although CAI has a history of about 35 years in Turkey, the computer was tried to be used as a supporter of the behaviorist approach. Computer was utilized as only a demonstration tool to support the teacher's instruction in the classroom environment so that it was not able to move away from the teacher-centered direct instruction method. However, the use of computers in teaching environments with a structural philosophy can help to create more efficient and functional learning environments. In such an environment, a student can interact with the computer so that controls his/her own learning process, can navigate through software within the scenarios that his/her teacher has already prepared or can design his/her own mathematical studies using the software available for his/her use (Baki, 2001, 2002; Baki, Güven & Karataş, 2002). When this situation is evaluated specific to mathematics emphasized in many studies (Herzig, 2002; Sarama & Clements, 2009; Yenilmez & Avcu, 2009) as difficult and hard to learn compared to other disciplines because of its abstract structure; the innovations that computer-assisted mathematics instruction (CAMI) can bring into learning-teaching environments should be taken into consideration. According to Baki (1996); "a more important feature than a computer can be used as an effective computing tool is its ability to embody abstract mathematical concepts by displaying them on the screen". This embodying process will positively affect students' meaningful learning. For this reason, the structuring processes for students' mathematical knowledge should be supported by multiple representations and materials, and students should be actively involved in using ICT during the mathematics learning process.

The use of dynamic geometry and algebra software in the CAMI activities performed in learning-teaching environments has led to the emergence of new understandings (Hohenwarter & Fuchs, 2004). For responding to these new insights, the most important software that will support mathematics education and be used to create positive teaching, learning and class environment, is Computer Algebra System (CAS) based on the use of symbolic expressions, and dynamic geometry software (DGS) focusing on geometric structures (Hohenwarter & Fuchs, 2004; Hohenwarter & Jones, 2007; Tatar, 2012). According to Ersoy (2005), when recent developments are taken into consideration, CASs are likely to become mandatory and standard instruments for teaching and learning mathematics.

The search for error-free and faster processing with the development of mathematics and technology, has emerged within the body of advanced calculators and various computer software. CASs are the products of this quest (Tuluk, 2007). CASs, which are developed as software that can make symbolic computation besides numerical computation for solving mathematical problems, have been obtained by extending standard numerical programming languages such as C, Pascal and Fortran (Aktümen, 2007). It is understood that the educational activities carried out through CASs positively affect students' levels of conceptual understanding (Aksoy, 2007; Ghosh, 2003; Kabaca, 2006; Sevimli, 2013; Sevimli & Delice, 2015), problem solving skills (Aktümen, 2007; Sevimli, 2013; Tuluk, 2007), academic achievements (Aksoy, 2007; Bulut, 2009; Stephens & Konvalina; 1999), operational skills (Bulut, 2009; Sevimli, 2013), mathematical thinkings (Bulut, 2009; Tuluk, 2007) and their attitudes towards mathematics (Aksoy, 2007; Aktümen, 2007; Aktümen & Kaçar, 2008; Kabaca, 2006; Tuluk; 2007). Likewise, similar results were emphasized in the literature reviews dealing with the teaching activities in which CASs had been used (Buteau, Marshall, Jarvis & Lavicza, 2010; Lavicza, 2008; Marshall, Buteau, Jarvis & Lavicza; 2012). These are as follows; students learn mathematics with a better and deeper understanding through CASs, CASs develop students' independent learning and success, CASs increase students' motivation for mathematics, CASs make simpler and easier to understand the difficult and realistic mathematical structures so that students can handle them in earlier periods, a new instruction that meets the needs of 21st century business areas takes place through CASs.

As a result of the relevant literature review; it is understood that there are very few studies in Turkey where CASs are used as a learning-teaching tool (Tatar, Kağızmanlı & Akkaya, 2013) and these studies have been carried out about general mathematics (Calculus) subjects, mostly with undergraduates, as in the international literature (Buteau et al., 2010; Lavicza, 2008; Marshall et al., 2012). On the other hand, it is understood that mainly CAS-based graphic calculators (Baki & Çelik, 2005; Pierce, Ball & Stacey, 2009) are used and the computer-based applications are not sufficiently addressed in the studies performed at the secondary education level (Pierce et al., 2009). Moreover, in many literature compilations, it is emphasized that data collection methods including the observations to understand classroom reflections of the CAS applications are not used sufficiently (Buteau et al, 2010; Lavicza, 2008; Marshall et al, 2012). It is thought that this study, which examines the reflections CAS usage in learning-teaching environments in which secondary school mathematics teachers and students are involved, will contribute in the literature in this respect. Besides the contributions of the study to the literature; it is also thought that the findings obtained as a result of classroom observations and teacher interviews may be a guide for those who want to use CASs such as Mathematica, in their lessons or researches.

It should be understood that the use of ICT in mathematics teaching will not simplify mathematics education but convert it into even more complex structure (Ersoy, 2005). The technology integration achievement in learning-teaching environments is a complex, dynamic, slow and long-lasting process without discrimination of levels (Groff & Mouza, 2008; Harris, Mishra & Koehler, 2007; Koehler, Mishra & Yahya, 2007; Usluel & Demiraslan, 2005). In this respect, it can be said that responsibilities of the teachers who have a key role in CAMI applications can be increased by providing effective technology integration because in the process of integrating technology into learning-teaching environments, authority is not only at the hands of teacher. The authority is dispersed among all stakeholders of the integration process, including technological tools. This situation, in turn, can cause teachers to face unpredictable problems in many ways (Bingölbali, Özmantar, Sağlam, Demir & Bozkurt, 2012).

According to many studies, while it is emphasized that the main actors in the use of CAMI in educational environments are teachers (Öksüz & Ak, 2009; Seferoğlu, Akbıyık & Bulut, 2008; Umay, 2004), but also it is also stated that one of the biggest factors that CAMI cannot take place in classrooms is teachers' inadequacies in this subject (Ersoy, 2005; Hangül & Devrim, 2010; Kutluca & Ekici, 2010; Seferoğlu et al, 2008; Yenilmez & Karakuş, 2007). As a matter of fact, it has been understood in some researches that many teachers do not know about the ICTs in schools (Kazu & Yavuzalp, 2008), and that they have negative opinions about CAMI because they cannot attribute a pedagogical role to computers in the classroom (Çakıroğlu, Güven & Akkan, 2008). While, as a result of some conducted studies, it has been emphasized that teacher and teacher candidates have positive views on the utilization of ICTs by ensuring their technology integration in learning-teaching environments (Arslan, 2003; Ersoy, 2005; Kutluca & Ekici, 2010; Öksüz & Ak, 2009; Seferoğlu et al., 2008; Yenilmez & Karakuş, 2007); it has been also understood in many studies that teachers cannot achieve the desired level of technology integration, even though they have these positive opinions and knowledge in particular about the use of technological products such as computers (Akkoç, 2007; Bauer & Kenton, 2005; Bozkurt & Cilavdaroğlu, 2011; Demir, Özmantar, Bingölbali, & Bozkurt, 2011; Demiraslan & Usluel, 2005, 2006; Kurtoğlu, 2009; Palak & Walls, 2009). It has been observed that teachers use computers with a teacher-centered approach mostly in order to make preparations for lessons, prepare administrative documents and change the environment in their courses (Demir et al., 2011; Kaleli Yılmaz, 2012; Palak & Walls, 2009). Therefore, it is not enough for teachers to have computer knowledge for effective technology integration; they have to be competent on technology, pedagogy, and content knowledge, as well as the types of knowledge resulting from their interaction with each other (Akkoç, Bingölbali & Özmantar, 2008). In this direction, the technological pedagogical content knowledge (TPCK) framework arising from the combination of the afore-mentioned types of knowledge has gained importance, as the technology integration is realized in the desired way (Mishra & Koehler, 2006).

Many studies in the literature emphasize that teachers should develop computer literacy, and that it is necessary to provide them with in-service trainings and to encourage them to use of technology in their classes, in order to realize CAI activities by ensuring the technology integration in learning-teaching environments (Çakıroğlu et al., 2008; Hangül & Devrim, 2010; Kılınç & Salman, 2006; Yenilmez & Karakuş, 2007). On the other hand, there is quite few numbers of studies that show how technology integration should be realized or how it is currently being realized in classrooms (Bingölbali et al., 2012). In this regard, in order to accurately determine the reflections of the use of the Mathematica program in mathematics instruction, firstly, it has been decided in the research that secondary education mathematics teachers should be given trainings in this subject. For this purpose, CAMI workshops were organized by the researchers, with the participation of secondary education mathematics teachers, in the context of in-service trainings. Then it has been decided to use the TPCK framework and technology integration levels of which effectiveness was proven in many studies, (Akkoç, Özmantar, Bingölbali, Demir, Baştürk & Yavuz, 2011; Bingölbali et al., 2012; Demir et al., 2011; Horzum, 2013; Kaleli Yılmaz, 2012; Özmantar, Akkoç, Bingölbali, Demir & Ergene, 2010) in order to determine the technology integration levels of the CAMI activities that teachers realized in their classrooms through Mathematica program during the content formation of these trainings and after the trainings.

1.1. Technological Pedagogical Content Knowledge (TPCK) Framework

Technology and theoretical framework are two integral parts of both the design and functioning of integration programs (Demir, 2011). Technological pedagogical content knowledge (TPCK) is a theoretical framework obtained by adding also the technology component to the concept of pedagogical content Knowledge (PCK) that Shulman (1986) has created, in order to provide technology integration in learning-teaching environments. The TPCK framework (Figure 1) focusing on the content, pedagogy and technology components of knowledge, suggests that the learning-teaching activities to be realized with technology support will arise from the dynamic relationship between these components, and defines how this interaction will occur (Mishra & Koehler, 2006).

Bozkurt and Cilavdaroğlu (2011) summarized contents of the components of content Knowledge, pedagogical knowledge and technological knowledge, as shown in Table 1.

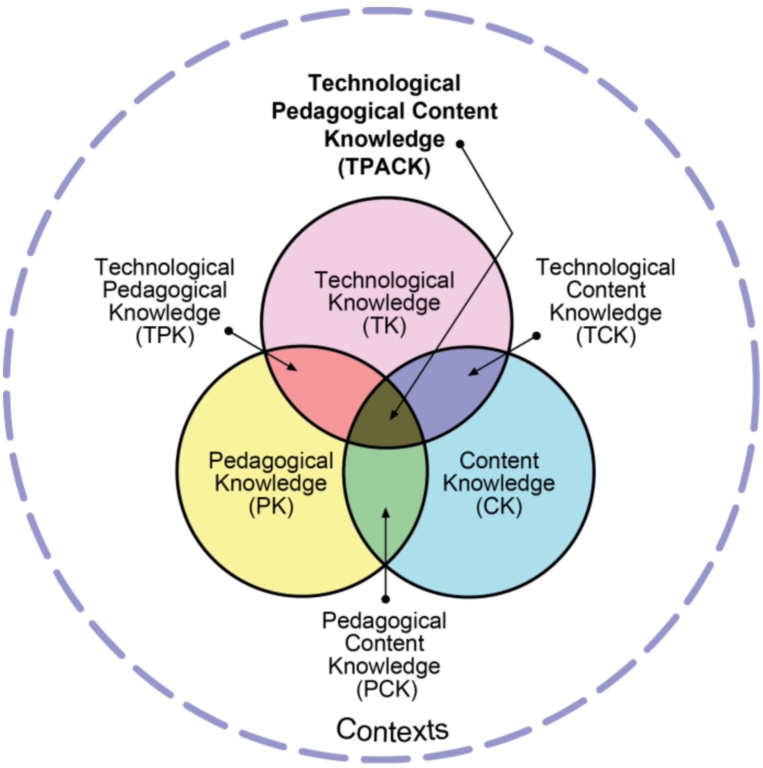

Figure 1. Technological pedagogical content knowledge framework and components (www.tpack.org)

Table 1. Contents of Content knowledge, Pedagogical knowledge and Technological knowledge

Content Knowledge	Pedagogical Knowledge	Technological Knowledge
Curriculum	Classroom management	Basic usage
Representation systems	Teaching strategies and methods	Standard settings
Student difficulties (what are they?)	Student difficulties, misconceptions (how to solve them)	Ability to solve technical problems
Measurement and evaluation (what?)	Measurement and evaluation (how?)	

Koehler and Mishra (2008) emphasized that the important things in their recommended model are the knowledge components as well as the pedagogical content knowledge, the technological content knowledge, the technological pedagogical knowledge and the technological pedagogical content knowledge, arising from the intersection of those information components. They also stated that these constitute a basis for the development of a good teacher (Mishra & Koehler, 2006).

1.2. Technology Integration Levels

Technology integration is the use of technological tools in curriculum in order to achieve the objectives set in the learning-teaching process and to strengthen the learning of students (Cartwright & Hammond, 2003; Bauer & Kenton, 2005). Hughes (2005) proposed three levels to determine the extent to which the technology usage in learning-teaching process is achieved. These levels have been finalized with the contribution of Demir (2011) by taking into consideration the cases where technology is not used.

Level-0: is the level at which technology is not used or technological activity directed to a specific purpose is not present (Demir, 2011).

Level-1 (Replacement): is the situation in which the use of technology provides only environmental change; but it is not used for different purposes or achievements (Akkoç et al., 2011, Hughes, 2005). The reflection of a problem that mathematics teachers can write on board through a projection can be given as an example at this level. In this case, the teacher utilizes from technology instead of the traditional materials that already exist in the classroom. In this activity, which can also be carried out without technology, there are no changes in the learning routines of the students (Demir & Özmantar, 2013).

Level-2 (Amplification): Effective and quick execution of the learning process without any change in tasks or targets is concerned at this level aiming of a facilitation by the use of technology (Akkoç et al., 2011; Hughes, 2005). Technological tools can be used to perform a number of activities in the learning-teaching process more effectively and quickly at this level in which radical changes in classroom routines and practices are not required (Demir &

Özmantar, 2013). For example, the situation in which a mathematics teacher draws graphs of equations quickly and accurately through a computer by using the Derive software during the instruction on linear equation systems is an example for technology integration at this level (Kaleli Yılmaz, 2012).

Level 3 (Transformation): is the level at which technology integration is realized in a way that the students can develop deep insights into a particular subject (Demir & Özmantar, 2013). Hughes (2005) stated that teachers' pedagogical approaches would change the classroom routines and they would achieve a high level of technology integration when they were provided with deep learning. With this level of technology integration, it is possible for students to understand the conceptual mathematical structures and to establish internal connections between these structures (Akkoç et al., 2011). For example, the activities to achieve a conceptual understanding with software that will help for establishing relations between different representations of the concept of function, such as algebraic, graphical and table, can be given as an example at this level (Özmantar et al., 2010; Demir & Özmantar, 2013).

1.3. Aim of the Study

This research where the level of CAMI activities carried out by teachers through CASs and the classroom reflections of these activities were tried to be determined before and after the trainings given to the teachers, aims to answer the following questions:

What level of technology integration does the mathematics teachers realize in their classes before the workshop?

At what level of technology integration did the mathematics teachers perform CAMI activities through CASs in their classes after the workshop?

2. Method

At the beginning of the research, CAMI Workshop was organized by the researchers within the scope of in-service training with the support of Adıyaman Provincial Education Directorate. In order to determine the participants before the workshop, official announcements were made to the secondary school mathematics teachers in the province. The workshop was held with the participation of 10 mathematics teachers. In this research, the findings of three teachers who were teaching 10th grade mathematics and working in different school types were presented.

Prior to the classroom practices, interviews and classroom observations were conducted to determine the extent to which participants performed their technology integration in their classes. However, in the classroom observations that were held before the workshop, three of the teachers did not take advantage of ICTs in their classes. For this reason, the classroom observations before the workshop were not included in the findings of the study.

The classroom practices of the three mathematics teachers through the Mathematica program on the graphs of quadratic equations (parabola) were observed and recorded by the researchers through video recording to prevent data loss. These practices lasted 18 hours in total, taking into account the length of time that teachers spend on their annual plans to graph the second degree functions. Teachers utilized from dynamic materials (nine pieces) and worksheets that researchers had prepared for their classroom practices during class time for six hours.

2.1. CAMI Workshop

Before starting the research, lecture notes were prepared for the CAMI Workshop, which will be conducted with the participants. During the workshop, an interactive virtual book was created by the researchers using the Mathematica 9.0 program in order to teach how to use the CAS program, Mathematica. In the workshop, the relevant dynamic materials on the subject of second-degree functions' graphics to be applied in the classroom environment firstly with the teachers and then with the volunteer teachers were developed based on the Mathematica, taking into consideration of the expert opinions and the achievements in the mathematics curriculum.

The CAMI Workshop was held as in the form of a total of 24 sessions, each of which was 50 minutes. It was aimed to give the theoretical information about the technology integration process, TPCK framework and CAMI in the first 5 sessions of the CAMI Workshop. In the next thirteen sessions, the general properties of the Mathematica program and the use of the Mathematica program in the teaching-learning environment were presented. In the last 6 sessions of the workshop, sample CAMI practices have been carried out through the worksheets and dynamic materials prepared about the graphics of second-degree functions.

2.2. Participants

Among the teachers who participated in CAMI Workshop, teachers who were to perform classroom practices by using the criterion sampling method included in purposeful sampling methods were identified. Criterion sampling method is the creation of observation units in a survey from the people, events, objects, or situations that have certain qualities (Büyüköztürk et al., 2010). While participants at this stage of the study were identified, it was decided to implement classroom practices with three teachers working in different school types, considering the criteria that the teachers should participate voluntarily, have the possibility to realize the CAMI in their schools, and instruct 10th grade mathematics course. Some of the information about the participant teachers are as shown in Table 2. The names of the teachers are coded as T1, T2 and T3.

Table 2. Some information of the participant teachers

Participant	Age	Gender	Professional Experience	School Type
T1	32	Female	8 year	Anatolian Vocational High School
T2	34	Male	10 year	Anatolian İmam Hatip High School
T2	40	Male	15 year	Anatolian High School

None of the participants had previously any training related to the use of technology integration or CASs in the courses. On the other hand, only T2 among the participants stated that he/she had received basic education about QBasic programming language during university education but did not perform any activities about computer programming later.

2.3. Data Collection and Data Analysis

In researches, it is generally difficult to get information about how the events occur even though it can be understood through interviews what the participants think about a topic or why they think it is so; from this aspect, observations can be used to obtain information on how these events take place in their natural environment (Çepni, 2009). The concept of "observation" defines "the process of gathering the data needed in the research by monitoring it with the naked eye or by using a tool, focusing on specific targets such as people, society or nature" (Büyüköztürk et al., 2010). In this direction, a series of semi-structured interviews and observations were conducted by the researchers to determine the level of mathematics teachers' ability to perform mathematics teaching through computer algebra systems.

While creating the observation form to be used in the research, a preliminary draft was drawn up by using the literature related to technology integration in CAI and learning-teaching environments (Akkoç et al., 2011; Aydın, Baki & Köğce, 2008; Baxter Magolda, 1992; Bingölbali et al., 2012; Demir, 2011; Demir & Özmantar, 2013; Hughes, 2005; Kaleli Yılmaz, 2012; Özmantar et al., 2010) and the sources providing information about scientific research methods (Büyüköztürk et al., 2010; Çepni, 2009; McMillan & Schumacher, 2001; Yıldırım & Şimşek, 2008). A semi-structured observation form draft was created by taking the opinions of three mathematics education experts related to the preliminary draft. Pilot practice was then carried out using the draft form. In the pilot practice, three mathematics teachers were observed during their CAMI activities through the Mathematica program for a total of 20 teaching hours. The observation form was finalized according to the results obtained in the pilot practice and the corrections made on the drafts in accordance with the opinions of the two field trainers.

Descriptive analysis method was used in the analysis of the qualitative data obtained in the research. According to Yıldırım and Şimşek (2008), the present data are summarized and interpreted in reference to the previously determined theme, in the method of descriptive analysis. The data can be organized according to the theme set out by the research questions, or by considering the questions or dimensions used in the interview and observation processes. While the way that teachers follow in the process of technology integration was examined by using the technology integration model proposed by Bingölbali et al. (2012), the extent to which technology integration had been realized in this process was analyzed by using the technology integration levels developed and contributed by Hughes (2005) and Demir (2011) respectively. The level of realization of the situations and behaviors in the observation form was evaluated as "Yes", "No" and "Partially". In order to ensure the reliability of the observation data obtained in the research, the recorded application videos were re-examined by video analysis method in the light of the observation notes, and the obtained results were reviewed accordingly. In addition, visuals and observation findings of the classroom practices were evaluated by two education specialists who had previously conducted research on the subject, and then a consensus was achieved on the results. Abbreviations of A1 (first activity) and A2 (second activity) were used when observational results from classroom practices were presented.

3. Findings and Results

Findings of the research were presented in two parts in order to demonstrate the extent to which mathematics teachers have participated in technology integration in their classes before and after the Workshop. On the other hand, observational findings of T1 were presented under a separate heading in order to get a better understanding of in-class reflections of the courses using Mathematica and to show which technology integration levels are being realized. Also, it was considered to receive a better understanding with this method on how the analysis of the observational data made.

3.1. Findings before Workshop

During the interviews made at the beginning of the research, participants T2 and T3 expressed how they use ICTs in their courses in the following way:

"We have a book loaded to our smart boards or flash drives. We load book, question bank and lectures... We reflect on smart board the book as it is or the source

book that we created. We give lecture to students in detail. The students can also follow it. There are questions that we prepared or questions that are in the book. Here there are students who want to solve the questions on the board or everyone solves these questions by themselves. "

"I usually use it to solve questions. Well, we give lectures on a normal white board. But we see the questions on the smart board and evaluate them together with the students. We give the questions to the students by getting these questions from PDF of the textbooks or the tests that we have prepared in the Word format, or the leaf tests etc."

On the other hand, T1 stated as follows that he/she could not benefit from ICTs in his/her courses because of his lack of training in technology use in the courses:

"I mean, I do not really have a good command of the computer anyway. I do not have training on the use of technology in courses as well..."

After the interviews, the courses of each of the mathematics teachers were observed by the researchers for two hours each. However, during the observations, no participant benefited from ICTs in their classes, even though they had access to many ICTs (computer, smart board, tablet computer).

It was understood in the examination made before the CAMI Workshop that T2 and T3 utilized from the ICTs for the reflection of course books to the smart boards and the solutions of sample questions during their courses. It was also understood that the participants benefited from basic computer programs such as MSWord and PDF Reader but not from CAS software such as Mathematica. It cannot be asserted that such an application is very different from traditional applications. It can be said that the use of ICTs in classroom in this way will not change the class routines, but only will change its atmosphere. Therefore, it is understood that prior to the workshop, technology integration in the classes of T2 and T3 was realized at the 1st level (replacement).

3.2. Findings after Workshop

The general observations of the classroom practices performed by the mathematics teachers after the workshop are presented in Table 3 as a whole.

Table 3. General Observational Findings of Classroom Practices

Categories	Teachers	Activities								
		A1	A2	A3	A4	A5	A6	A7	A8	A9
Was there a need to use technology for the product that needs to be introduced in the activity?	T1	Y	Y	Y	Y	Y	Y	Y	Y	Y
	T2	Y	Y	Y	Y	Y	Y	Y	Y	Y
	T3	Y	P	Y	Y	P	Y	Y	Y	Y
Have the worksheets and guidelines for the activities to be realized been given to the students on time?	T1	P	Y	Y	N	Y	Y	Y	Y	Y
	T2	Y	Y	N	Y	Y	Y	Y	Y	Y
	T3	Y	N	Y	N	Y	N	Y	Y	Y
Did the students have difficulty in understanding of the instructions regarding the worksheets or computer programs used in the activities?	T1	N	N	Y	N	Y	N	N	N	N
	T2	N	N	N	N	N	N	N	N	Y
	T3	Y	N	N	N	N	N	N	N	N
If so, did the teacher help the students?	T1	-	-	Y	-	Y	-	-	-	-
	T2	-	-	-	-	-	-	-	-	Y
	T3	Y	-	-	-	-	-	-	-	-
Was there any student who did not involve or able to involve in the activities?	T1	Y	N	N	N	N	N	N	N	N
	T2	N	N	N	N	N	N	N	N	N
	T3	N	N	N	N	N	Y	N	N	N
If so, did the teacher help these students to get involve in the process?	T1	Y	-	-	-	-	-	-	-	-
	T2	-	-	-	-	-	-	-	-	-
	T3	-	-	-	-	-	Y	-	-	-
Has the teacher experienced any technical problems with the technological products or programs used during the activities?	T1	N	N	N	N	N	N	N	N	N
	T2	N	N	N	N	Y	N	N	N	N
	T3	P	N	Y	N	P	Y	Y	Y	Y
Did the teacher highlight the elements needing attention in the activities?	T1	Y	Y	Y	Y	P	Y	Y	Y	Y
	T2	Y	Y	Y	Y	Y	Y	Y	Y	Y
	T3	Y	Y	Y	Y	Y	Y	Y	Y	Y
At the end of the events, did the teacher make any explanations about the benefits that should have been acquired?	T1	Y	Y	P	P	N	Y	Y	Y	Y
	T2	Y	Y	Y	Y	Y	Y	P	Y	Y
	T3	Y	Y	Y	Y	Y	Y	Y	Y	Y
Did the teacher's interventions with the students during the course of the events support the intellectual activities of them?	T1	N	Y	Y	Y	Y	Y	N	Y	Y
	T2	Y	Y	N	N	Y	Y	Y	Y	Y
	T3	Y	P	Y	N	N	Y	Y	Y	Y

Y: Yes, N: No, P: Partially

Table 4. Technology Integration Levels of CAMI Practice by Teachers through CASs

	T1		T2		T3	
	Yes	Partially	Yes	Partially	Yes	Partially
Level-0						
Level-1						
Level-2	A1, A7		A3, A4		A4, A5	
Level-3	A2, A6, A8, A9	A3, A4, A5	A1, A2, A8, A9	A5, A6, A7	A1, A3, A6, A7, A8, A9	A2

CAMI practices were carried out by the mathematics teachers in technology classes of their schools. In the classes where the practices were carried out, it was understood that there were interactive boards, projectors and a number of computers that could be used by students. It has been observed that the PCs in the technology classes where T1 performs CAMI activities are new and have quite good hardware. This situation may have been due to the fact that the school where the implementation was carried out was Anatolian Vocational High School. On the other hand, it has been observed that the PCs in the technology classes where T2 and T3 perform CAMI activities are outdated. However, computers were able to carry out the CAMI activities prepared in the Mathematica program at the needed level.

During the CAMI activities, T1 set up a class organization in the form of each student having a computer, while T2 and T3 used a class organization with student groups. It has been understood from the observations that the reason why T2 and T3 choose such class organization is the inadequate number of computers for each student. Even though the teachers have allowed the students to exchange ideas among themselves, they have asked them to reflect their individual inferences to their worksheets. Similarly, in the discussion and question and answer environments created in the classrooms, it has been observed that the students are included individually in the process and not in groups.

All of the three teachers explained about how to use the CAMI activities prepared in the Mathematica program for their students at the beginning of class applications in about 10 minutes. It was considered that this training duration is sufficient for the students.

Almost all of the students in all three practice groups were observed to be involved in all activities. This may have been due to the fact that the teachers were successful in their classroom management and the CAMI activities were interesting for the students. In addition, the factors that keep the students interested in the CAMI activities include the motivating guidance of the teachers for their students to interact with computers and their inclination to help the students who are not involved in the process appropriately. On the other hand, it was observed during the course of applications that some of the students encountered technical problems and the teachers solved the related problem in a short time, thus preventing the students from losing motivation for the lecture. Of course, the level of technology knowledge of teachers is also important in resolving such technical problems.

As a result of the observations, it has been understood that the teachers adopting a student-centered approach along with classroom practices have generally encouraging role on the students to realize their own learning through using computers and worksheets. It can be argued that this positive attitude of the teachers contributed to the change in learning routines of the students and to their deep understandings with their individual efforts. In the light of these data, it is understood that, after the CAMI workshop, the teachers endowed with technology integration at the level of amplification (Level-2) and transformation (Level-3) by using CASs as they did not before (Table 4).

3.3. Observational Findings of T1

When the possibilities of the school where the T1 is working are examined, it was understood that the school had three technology classes in which CAMI activities could be performed. There were 16 computers with all necessary software, projectors and smart boards in the environment where the CAMI activities were carried out (Figure 2). The class organization with a computer per two students was designed by T1 and the students were let to sit where they wanted. It was observed during the CAMI activities that the students interacted with their colleagues and exchanged their ideas, but they individually performed activities on the worksheets and computer applications.

Figure 2. Visual images directed to physical conditions of the technology class where T1 made practice

After identifying the class organization at the beginning of the first lesson, T1 practically introduced the

Mathematica program to be used during the CAMI activities, in about 10 minutes, and mentioned what differences the course would have from the previous ones.

The observations showed that students were initially surprised about the teaching of mathematics course in the technology class, and that they were eager and interested in the course on the advancing time. Also it has been observed that T1 motivated the students to use computers during the course, and explained what kind of facilities these computers could provide them in their activities.

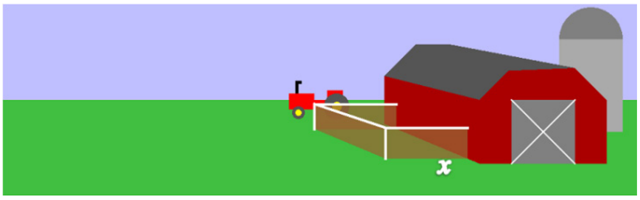

Figure 3. Screenshot of A4

In the majority of CAMI activities (except A4) carried out by T1, he/she gave worksheets and directions to the students in a timely manner. In the fourth activity, the students were told that the remaining three sides of the garden, one of which was closed by the barn, wanted to be closed with a fence wire of 200m long and then they are wanted to create a function to calculate the area of the barn that would be constructed (Figure 3).

It was observed that the students used computers even though they had to perform the activity without getting help from their computers in the first place. T1 recognizing this situation then made a warning that he/she had to make at the beginning of the event, and ensured that the relevant students had closed the program prepared for A4. Then T1 created a classroom discussion environment and got student views on how could be the function to be used for the area calculation.

He/She asked one of the students who did not get help from the computer to write the function that he/she found, by calling him/her to the board (Figure 4).

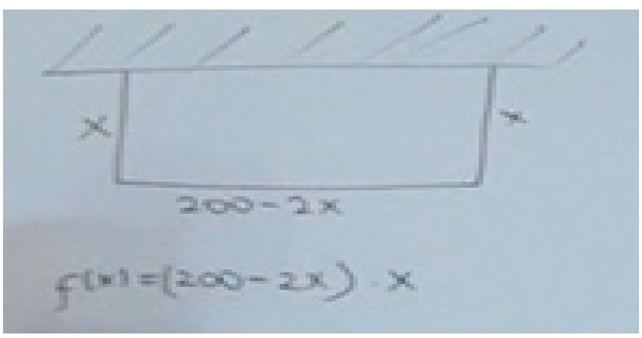

Figure 4. A student solution of A4

It has been observed that it was difficult for the students to understand some of the directives in the worksheets or computer programs used in the activities that T1 performed. One of the students stated that he/she could not understand the concept of "direction of the arms of parabola" expressed in the worksheets at A3 and he/she had a conversation with T1 as follows:

Student A: *Teacher, this question asks direction of the parabola here. What it means by the direction?*

T1: *Look, you are asked about direction of the parabola's arms. There is openness like in the shape of bowl, the question asks you find the direction that it looks at, and I mean the directions of the arms stretching out beside it.*

[Raising student his/her arms to the upside]

Student: *Ha ... Is that upwards and downwards like this?*

T1: *Yes, it is, there are only two options.*

Similarly, in A5 (Figure 5), some of the students did not understand the following directive on the worksheets: "$f: R \rightarrow R, f(x) = ax^2 + bx + c$ and $(a \neq 0)$ is a second degree function with given properties. Please open '5.cdf' program and create a question that ensures the conditions stated in the Table below, by using 'a, b and c' bolt that controls the coefficients in the f function, then draw the shapes created on coordinate axis". T1 firstly reminded the students that the value of "Δ" depends on the coefficients "a", "b" and "c" and told them to perform these drawings in such a way as to provide the conditions given to them on the worksheets with the help of computers. Later, T1 solved an example on his/her own computer so made the students understand the situation.

It was observed that only some of the students during A1 did not participate in activities by having extra-curricular activities on computer. When T1 realized this situation, he/she went to the students, silently warned them and asked them to participate in activities. After this warning, the students participated in A1. This may have happened due the fact that students had been involved in mathematics classes in such an environment for the first time. As a matter of fact, it has been observed that all of the students participated with interest in all of the activities except this activity.

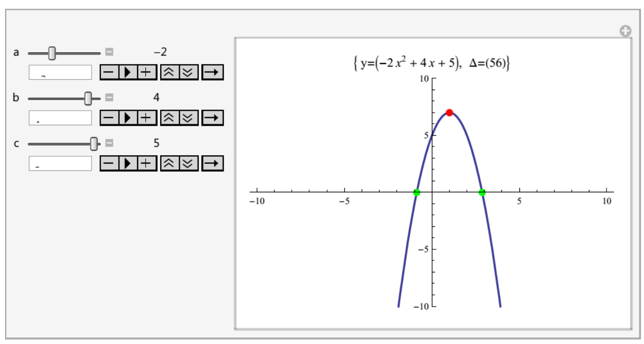

Figure 5. Screenshot of A5

T1 made the necessary emphasis on almost all of the activities that needed to be paid attention. Similarly, he asked the class about the achievements that should be taken at the end of all events except A3, A4 and A5, and checked whether the achievements were gained. The following conversation between T1 and his/her students at the end of A2 can be given as an example:

T1: *Now, please tell me what have we learned about this activity? Who is going to say it?*

Student B: *Now, Teacher, because the sign in front of the function of* $f(x) = x^2$ *is positive (plus), so the function goes upward. But the sign in front of the function of* $f(x) = x^2 + 3x + 4$ *is negative so the function goes downward. And also Teacher, there is a symmetrical thing of the parabola like this, I mean, it's both sides are same…*

T1: *Yes the parabola is symmetrical. What else?*

Student C: *Teacher, it also takes same values after a while.*

T1: *What else?*

Student D: *If the parabola is upward, then Teacher, it has the smallest value, and if it is downward it has the greatest value.*

T1: *Yes, good! Is there any question? Now, is there anyone who says "Teacher, I do not understand here in the question, I mean is it clear?"*

At the end of A3 and A4, it was observed that after T1 was interested in the students who had questions on the current activity, he/she was conceived that all the students responded to the questions on the worksheets then he/she began to another activity without answering the questions all together with the students in the class environment. On the other hand, during fifth activity, T1 begun the new activity by telling the students that: "You already see how you will do it on a computer. We do not have to answer again". Thus, T1 ignored at the end of the activity that the students might have been unaware of the points in the activity, and also he/she did not emphasize the achievements that had to be acquired at the end of the activity.

It can be asserted that most of the interventions that T1 has made to the students during the CAMI activities (all except A1 and A7) affected their intellectual profundity positively. There were two parts in A1's worksheet similar to each other. In the first part, students were asked to specify a set of points equidistant from a fixed point and a fixed line in the analytical plane. In the second part, they were asked to perform this process by using the computer (Figure 6), so that the students were aimed to discover the relationship between the drawing they made and the drawing that should be. In the second part of the activity, T1 showed the final figure to the students by showing the figure on the screen before he/she directed his students to computer use, and then he/she made various inferences on it. Although T1 has provided the opportunity for students to deal with the related subject on computer later on, the students did not have the opportunity to interact with the computer and make individual inferences.

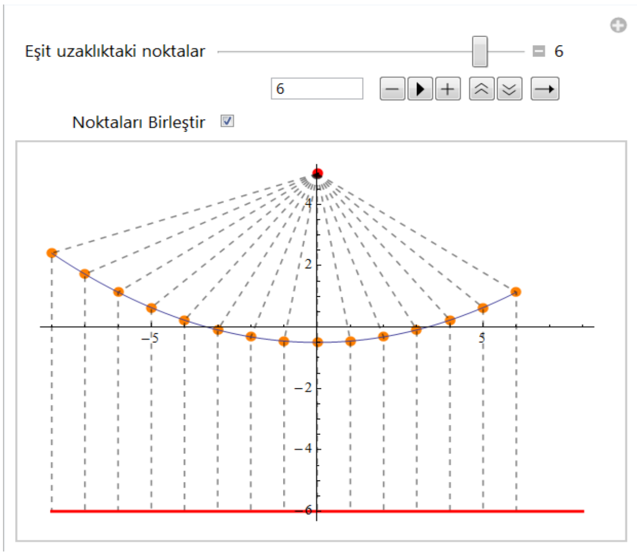

Figure 6. Screenshot of A1

During A7, the students were firstly asked to find out the type of arithmetic operation for the peak point of a parabola by receiving help from the computer program (Figure 7), and then to discuss and shape their ideas in class environment. They were also asked to find a general method to easily find the peak point of any second-order function given as $(x) = ax^2 + bx + c$.

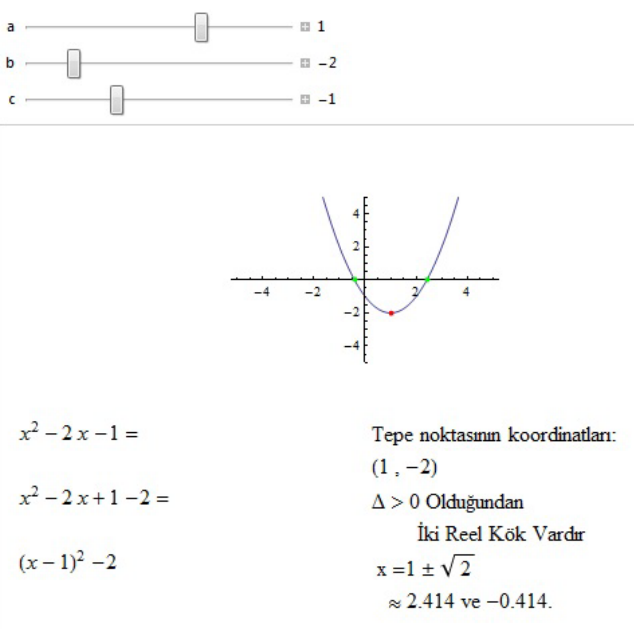

Figure 7. Screenshot of A7

In the first part of the 7th activity, T1 gave enough time for the students to answer questions on the worksheets by getting help from computer and then to make the necessary inferences. Afterwards, the related questions put by T1 were answered with participation of the students. However, T1 did not asked the students the question related to how to find the peak point of a parabola given as f(x)=ax^2+bx+c at the end of A7, but told them that the mathematical procedure to be carried out was "completion to perfect square" and found the result by making the relevant and necessary procedures on the board. This situation draws attention as a restrictive factor for students to realize their own learning.

The findings of observations on the extent, to which the technology integration into the teaching environment was realized during CAMI activities performed by T1 through the Mathematica program with CAS software, are given in Table 5.

Table 5. Technology Integration Levels in the Activities Performed by T1

Technology Integration Levels	Yes	Partially
Level-0: No use of technology		
Level-1: Replacement		
Level-2: Amplification	A1, A7	
Level-3: Transformation	A2, A6, A8, A9	A3, A4, A5

It can be said that during the CAMI activities performed by T1 through the Mathematica program, all activities except A1 and A7 were realized at the level of transformation, which is the highest step of the technology integration in teaching environment. T1 supported the students in all activities to benefit from computers and made motivational explanations about the necessity and use of technology. In almost all of the activities, the students interacted with the computers, reflected their inferences on worksheets and exchanged their ideas through teacher-created classroom discussion environments. Thanks to this atmosphere created by T1, the course became student-centered and an efficient learning environment was achieved with the participation of all students. It can be said that, during the activities in which the learning environment was established, the students obtained the desired achievements by depending on their own conclusions about the subjects requiring of deep understanding. Apart from this, T1 did not create a clear environment during A3, A4 and A5 for the exchange of ideas with the participation of the whole class at the end of the activities about the achievements to be gained by the students, and he/she was only interested in some students on an individual basis. The fact that this kind of behavior can create matters not provided for the learning of other students, draws attention as a partial deficiency. Although the students were given enough time to interact with the worksheets and computers during A1 and A7, T1 explained the necessary procedures on the subject of the achievements needed to be gained at the end of the activities, directly by writing on board without asking the students' views. This situation may have prevented the students' individual learning from being carried out at the desired level.

4. Conclusions and Recommendations

While the mathematics teachers were observed, it was not only examined whether they used ICTs but also the effects of activities performed by them on class routines. This is because teachers' pedagogical approach will provide a high level of technology integration when they change class routines and provide them with deep learning (Hughes, 2005). Before the CAMI Workshop, two of the teachers stated that they used ICT in their courses. This usage has been realized at the level of replacement (Level-1), as in many studies in the literature (Akkoç, 2007; Bauer & Kenton, 2005; Bozkurt & Cilavdaroğlu, 2011; Demir et al., 2011; Demiraslan & Usluel, 2005, 2006; Kurtoğlu, 2009; Palak & Walls, 2009). It was understood that this use of ICTs provided only environmental changes but did not lead to any changes in learning-teaching routines.

The mathematics teachers performed 6 of the activities that they applied after the CAMI Workshop at amplification level as the 2nd level and also carried out 21 of them at transformation level as the 3rd level. This situation leads to the conclusion that mathematics teachers have made progress in realizing CAMI through ICTs by providing high level of technology integration in their courses. This result supports the findings indicating that both the teachers who were trained on technology integration (Bingölbali et al., 2012; Demir, 2011; Kaleli Yılmaz, 2012) and the participants of the studies in which mathematics teacher candidates were involved (Akkoç et al., 2011; Özmantar et al., 2010), have made progress in this respect.

In-service trainings can be given to the teacher in order to enable them to benefit from the ICTs by realizing the technology integration at the upper levels in their courses. It is necessary but not enough to train the teachers on how to use ICTs in technical manners during these trainings. In order for ICT usage to contribute to mathematics education in the desired direction and level, teachers can be trained about TPCK framework, technology integration process, CAMI and CASs such as Mathematica program. The CAMI Workshop held during the research process may be a model for which the relevant persons can get ideas for organizing these kinds of trainings.

Nearly all of the CAS software used today was created in English. The researchers or teachers whose native language is not English and who want to study in this area should pay attention to this situation. In overcoming this difficulty, it may be advisable to convert the relevant CAS program language into the user's native language. As an alternative, the course content within in the context of CAS trainings may include vocational English education as needed. In addition, preparing interactive documents or lecture notes in the native language of participants about the topic of the CASs can help addressing the participants' difficulties in this regard.

The dynamic materials and worksheets used in courses are very important for the realization of a high level of technology integration. For this reason, it is necessary for teachers or researchers to design the relevant worksheets and dynamic materials well before starting the activities related to the CAMI. It may be suggested that the ministries of education present the required worksheets and dynamic materials to teachers as available. On the other hand, various internet platforms can be created where researchers and teachers can share worksheets and dynamic materials that they develop, and also in which developers can exchange their ideas and experiences. Teachers and researchers can benefit from the freely available dynamic materials published by Wolfram, the maker of the Mathematica program and one of the current international web sites where teachers and researchers share materials about CASs (demonstrations.wolfram.com).

After identifying the activities and materials needed by teachers who want to use CASs in their lessons in accordance with achievements of the issue, they can perform classroom applications using the "technology integration tracking form" in which the questions on the observation form used in the research are also included (Appendix 1). This form can be proposed as a standard that teachers can track in the planning and implementation of the lesson to create a classroom environment where technology integration is provided at a higher level.

In the research, teachers used worksheets and dynamic materials prepared by the researchers in the course of class practices. In different researches on CASs, it is possible to investigate the suitability of worksheets and dynamic materials developed by teachers for educational activities. In addition, the in-class reflections of the practices that teachers perform with the products they have developed can be examined.

It can be mentioned that one of the main differences that distinguishes CAMI from traditional teaching methods is that students interact with computers and make individual inferences about the relevant subject. This interaction is usually provided by dynamic materials. In order to move the students' interaction with computers to higher levels, they can be trained on CASs like Mathematica. In this way, students do not only use the dynamic materials presented to them but also can create their own computer programs related to mathematical structures. Moreover, on this account, teachers will be able to give their students homework for which they can utilize from CASs in different ways. Likewise, the use of CASs can be achieved during the measurement and evaluation phase by enabling students to use CASs at more advanced levels.

It has been observed in the study that in the classes in which the CAMI practices were carried out, the teachers adopted an individual class organization in which each student made his own conclusion about the topic and transferred them to the worksheets and expresses them in classroom discussion environments. Therefore, the results obtained in the study are the products of the individual efforts of the students. From this point of view, it can be suggested to carry out different studies addressing cooperative learning environments in which students can perform CAMI activities in groups through CASs.

In order to better understand the effects of CAMI activities through the CASs in the direction of the technology integration process, new studies in which different topics of mathematics and geometry are addressed, can be conducted. Thanks to these studies, it can be ensured that the teachers, who want to benefit from CAMI in their courses, have ideas on what level of technology integration on which subjects they will realize, and also about the issues such as the possible positive and negative aspects of the relevant process and the effects of these aspects on students' success. The realization and dissemination of CAMI at the desired level will in particular require researchers studying in this field as well as their guidance. Both quantitative and qualitative increase in the number of researches conducted/to be conducted for CAMI, especially those involving mathematics teachers, can make significant contributions both in terms of the relevant literature and the inclusion of CAMI activities in classes.

Appendix 1

Technology Integration Tracking Form

Class: **Classroom Type:** Ordinary class Computer Laboratory Other:

Issue: **Activities:** **Date:**

The items in this form set out some steps about the process that teachers need to follow to integrate technology in their class. These items can be changed, added or removed if deemed necessary during the implementation process, in accordance with the nature of the activities performed.

1) How was a class organization organized according to the technological tools available in the environment?						
Technological tools	Available	None	**Number**	**Class organization**	Yes	No
Projector				whole Class		
Interactive board				small groups		
Computer				Individual		
Tablet computer				**Comments:**		
Other						

Items	**Y**	**P**	**N**	**Comments:**
2) Have students been taught how to use dynamic materials or software before the events begin?				
3) Was there a need to use technology for the product that needs to be introduced in the activity?				
4) Have the worksheets and guidelines for the activities to be realized been given to the students on time?				
5) Did the students have difficulty in understanding of the instructions regarding the worksheets or computer programs used in the activities?				
➢ If so, did you help the students?				
6) Are there any student who not involve or able to involving in the activities?				
➢ If so, did you help these students to get involve in the process?				
7) Did you highlight the elements needing attention in the activities?				
8) At the end of the activities, did you make any explanations about the benefits that should have been acquired?				
9) Did your interventions with the students during the course of the activities support the intellectual activities of them?				
10) Have you experienced any technical problems with the technological products or programs used during the activities?				
➢ If so, have you tried to overcome these problems?				
11) Which level did you implement technology integration into the teaching environment in the course of the activities?				**0.** None
				1. Replacement
				2. Amplification
				3. Transformation

Y: Yes, N: No, P: Partially

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