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Interactive Whiteboard in Mathematics Education

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Abstract. The spread of IT devices has great influence on present day society, and it has entirely changed our everyday life by becoming an organic part of it. We could not imagine a life without such devices. This influence is manifested in education and in schools, as well. New ICT devices have appeared and offer new possibilities for the teachers. It is a long process until education is totally reformed, the digitalisation and interactive development of teaching books happen, and teaching methods change. Teachers educate a digital generation, who use the ICT devices in the daily learning process and who easily acquire the usage of this equipment without extra instructions. The members of this generation should be taught with the help of digital pedagogy. More and more teachers learn how to use these devices and make them part of their everyday teaching, preferring mainly the IWB. (The Interactive Whiteboard – IWB – is an ICT device that gets connected to a projector and a computer, and projects the monitor of the computer onto the board on which one can realise interaction using special devices, pens or fingers.) The number of teachers using the interactive whiteboard is increasing in Hungary. Mathematics teachers are open, enthusiastic and curious about using the IWB in lessons; they do their best to learn how to use and make use of it. Experience also supports this idea since students' attitudes towards the IWB are positive. This paper aims at presenting the potentials of using IWB in mathematics lessons, the potentials of the software which is available for teachers, and the opinion of the students, which is given by means of concrete examples.

Keywords: IWB (interactive whiteboard), mathematics education, CAS (Computer Algebra System), DGS (Dynamic Geometric System), interactive learning environments

Introduction

After the appearance of the traditional blackboard, the computer and the IWB may have an impetus effect on teaching methods and on the renewal of the techniques. The first revolutionary teaching tool – the humble blackboard – found its way into classrooms back in 1801 and had a profound impact on the nature of teaching over the next 200 years. The blackboard became synonymous with the traditional classroom and, along with shiny red apples, it is still seen as a stereotypical symbol of education. The interactive whiteboard – or IWB – has the potential to be the second revolutionary teaching tool. Just as the blackboard was seen as a key part of nineteenth- and twentieth century classrooms, the IWB has the capability to become synonymous with the new digital classrooms of the twenty-first century (Betcher and Lee 2009).

The spread of IWB is varied, as we may find some schools where there is not any, in others there may be one, or quite the opposite, the number of these boards can be 10–15. It can be observed that the number of IWBs correlates with the number of the teachers who use them. The presence of IWB motivates the teachers to try it and use it in their pedagogic activities.

Maths and IWB

Mathematics is not the most popular subject with students. Many of them have not acquired the basic skills and have not taken enough time to practise, therefore they cannot catch up with the others, the lessons become more and more difficult for them to understand and they may even suffer during math lessons. Mathematics must rather be understood than studied. According to Duval, representation is the basis of understanding in the field of mathematics (Duval 1999). Using mathematical programs in the lessons seems to help representation. The acquisition of mathematical skills needs continuous study and thinking, since gaining and developing knowledge in maths is like building a pyramid: if there is no appropriate base, it is very difficult to build on it. Counting a lot may seem to be boring for a lot of students. Students often complain, saying that they do not like mathematics because it is too abstract, it contains only numbers and letters. Mathematics is a very important subject, therefore it must be made interesting, enjoyable and easy to understand for students.

The IWB and appropriate mathematical software are very good devices to facilitate representation and motivation. According to Lerman and Zevenberg, there is little doubt that IWBs have the potential to enhance learners' opportunities to experience mathematical representations and develop their mathematical thinking (Lerman and Zevenberg 2007).

By using them, we can easily represent functions and solid mathematical shapes; they are easier to see and one of their advantages is the fact that the teacher can modify them at any time. Using the board may make students more interested, because it makes it possible to emphasise practical use and involve them in the lesson, thus making the lesson more interactive, and providing the students with positive experience in order to make them see the beauty of mathematics.

The earlier survey by Tataroglu and Ayten, concerning the question whether students' attitude toward mathematics changed when using the IWB in math lessons, also supports the following claim: "Did your interest towards mathematics change after using the IWB?" were examined, it was determined that the interests of 9 (of 16) students towards mathematics increased after the lessons with the IWB. Students, who think that their interest increased, stated that it was because of their curiosity about the board, the simplicity of drawing, its ability to save time, the enjoyment of the lessons and visuals (Tataroglu and Ayten 2010).

Problem solving

In teaching mathematics, the teacher's task is to develop the intellectual competences of the students (Szalontai 2008). Thus, while solving mathematical problems, students' problem-solving skills also improve. There is a very good sequence of steps proposed by Pólya (1994), which may be very useful in helping students think while solving problems. These steps are the following:

1) understand the task;

2) find connections between the data and the unknown variable, if you cannot find any immediate connection, search for related problems, finally, make a plan;

3) carry out your plan;

4) examine your solution.

The above steps may be assisted by an interactive whiteboard. On the one hand, it can be used to illustrate the material; on the other hand, it is very good for making plans and finding connections. In addition, finding related problems is also easier with an IWB. The mathematical programs provide a fast and easy technique to check the solutions.

Fitzallen (2005) puts great emphasis on the recognition of a need for teachers to gain an understanding of how Information and Communication Technology (ICT) can be used to extend students' thinking and problem-solving skills, rather than being just a publication and research tool.

Using mathematical programs in lessons

The appearance of the computer was followed by the introduction of different calculators and other mathematical programs, which were designed to solve complex

mathematical problems that otherwise could not be calculated manually. These programs generate the results of the tasks automatically. However, some programs are for teaching purposes, helping the understanding and practice of the results.

The new devices and the different algebraic and geometric programs provide a lot of opportunities for school use. These programs might be divided into two groups: CAS (Computer Algebra Systems) and DGS (Dynamic Geometric Systems). Computer Algebra Systems appeared at the beginning of the 1980s. They are interactive programs which allow mathematical calculations containing symbols compared to those allowing only numerical calculations (Sárvári 2004). They might be systems with general purposes, e.g. Maple, Maxima, Derive, MuPad, MuMATH, DoCon, Mathematica, MathCAD, Reduce, and systems with specific purposes, which have reference to only one branch of mathematics, they can only solve one particular problem, for example differential equations or problems of group theory like Cayley, Gap, Kant.

Dynamic Geometric Systems that can be used in schools are, for example, the following: Euklidesz, Cabri, Euler, Cinderella, etc. Students like playing, especially with geometric programs by which they can easily make 2D and 3D shapes, they can easily modify these shapes and, according to the program's facilities, they can define different mathematical concepts or values. It is therefore not surprising that Interactive Geometry obtains more and more attention in many educational institutions. Around 25% of the countries within the EU refer explicitly to DGS in their national curricula or guidelines, and roughly 40% refer to ICT in general. Additionally, although the remaining countries do not mention ICT, some of them recommend the use of DGS in schools (Hendriks et al. 2008).

A distinction must be made between programs appropriate for using at primary and at secondary schools. Programs which are more colourful and playful are better to use at primary schools; such programs are Manó Matek, Geogebra and Euklidesz. Programs like Maple, Matematika or Matlab, which are more difficult and require the knowledge of the specific language of the program, may be used better at secondary schools and higher education, or in study circles.

The role of the teacher in lessons using ICT devices

It was observed how and how often teachers use ICT devices and what programs and digital material they use. With the use of ICT devices, teaching methods are also renewed. The question is how the new digital devices can be fitted into the traditional teaching methods in lessons.

The teacher's role changes in an ICT environment:

According to Kennewell (2005), the teacher is:

1) a consultant – providing information, such as prepared 'answers' for discussion; planned or ad hoc Internet searching; exploring simulations;

2) an organiser – providing tight structure but also unpredictable results for activities, such as games, so that the teacher is free to discuss strategies with the students as equal participants;

3) a facilitator – providing looser structure for focusing or construction activities involving choice, such as annotating or matching tasks, where teachers/ students can discuss options and guide the less knowledgeable;

4) a repository – enabling student ideas to be recorded for later revisiting, reflection and revision.

In connection with teachers' roles, Betcher and Lee (2009) have proposed eight key principles for effective IWB teaching:

1) be proficient;
2) be organised;
3) be interactive;
4) be flexible;
5) be constructive;
6) be open minded;
7) be willing to share;
8) be prepared to plan.

The above characteristics and skills make the teacher have a different role than in traditional lessons. They need to pay attention to more things: apart from the students, they also have to make sure that the devices work properly.

ICT devices in Ady Endre Secondary School

Teachers put great emphasis on ICT development in Ady Endre Secondary School in Debrecen, Hungary, which can easily be seen when taking a look at the school's equipment. Teachers have internet access everywhere in the building, there are PCs in teachers' offices and in the labs, and there are portable computers, as well. There are several interactive whiteboards, some of which are fixed, and others on portable cupboards with ICT devices and projectors (Dobránszky 2008).

Picture 1. shows a portable cupboard which contains ICT devices to help the use of IWB. They are very practical because they can be moved from one classroom to the other.

Picture1. Portable cupboard.

Since the IWB and the ICT devices are very popular with teachers in the school, they made a schedule to distribute these devices among themselves.

Below, the use of the ICT devices will be analysed via observations and experiments. It should be highlighted that these observations were made in bilingual classes.

Observations in lessons using ICT devices

Students' reactions and methods of teachers using ICT devices were observed during different lessons.

Mathematics lesson in class XI.

The topic of the lesson was the square root function and plotting functions, and the lesson focused on practice.

The following competence areas were improved: mathematics, digital and social competences, creativity, combinative skills, problem solving and development of thinking.

The only ICT device used was the IWB.

Learning organisation consisted in: frontal work, individual work and then common discussion, group work.

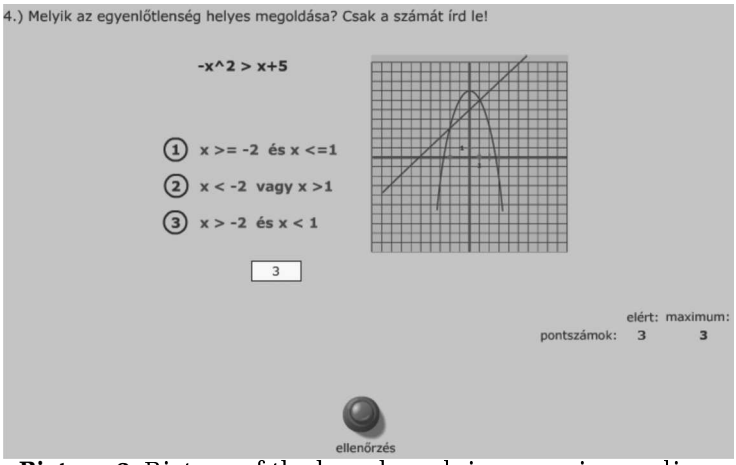
The structure of the lesson consisted in a quick pre-test, the pupils had to solve the following equations in 10 minutes:

$$y = x^2 - 6x - 4$$
$$y = -|x - 3| + 2$$

In the meantime, the teacher set the IWB.

The pre-test was followed by the discussion of the task and corrections verifying and resolving the homework.

Picture 2. shows the online solving of the exercises and the plotting functions.



Picture 2. Picture of the board – solving exercises online.

A lesson of practice followed, where students solved a series of problems in groups of two, then compared and checked their results with the help of IWB.

A pupil dictated the solutions of the tasks to another one, who typed it. After each solution, the problems were explained, supplemented and corrected.

A lot of time was gained with the help of the online problem solving program, since the teacher did not have to write the text of the problem on the board, and the plot of the function was drawn by the program, too. This way the plot was more precise, and it was easier to magnify then any handmade plots.

Students could compare the geometric and algebraic solutions. While solving the problem, the students could improve their visual thinking, their plain orientation, communicative skills, calculating skills and their skills of association.

We could see a dynamic and excellent lesson, which started by checking the homework and revision. In the practice stage, the interactive whiteboard played an important role. The above picture shows the list of problems the students had to solve in a cooperative way. The different answers were marked on the board by different students. It was evident that the students used the IWB with ease – they knew the functions of the board (writing, deleting, drawing, etc.) very well. The IWB was used all through the lesson and the students' attitude was very positive.

Physics lesson in Class XI.

The lesson topic was Gay Lussac's second law, the type of lesson was teaching new material and practice.

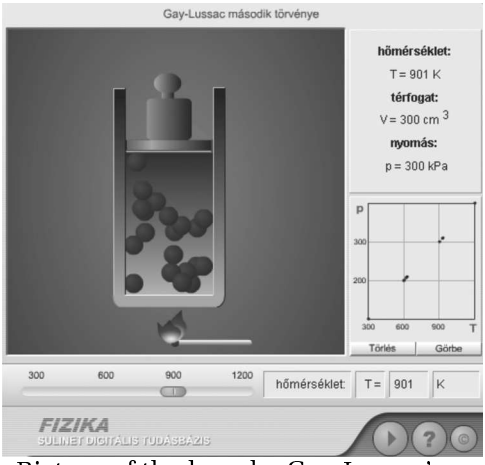
The improved competence areas were: mathematic, digital and social competences, creativity, combinative skills, problem solving, and the development of thinking.

The only ICT device used was the IWB.

Learning organisation consisted in: frontal work, individual work, then common discussion and group work.

The structure of the lesson included revision as the first step. The teacher elicited the material learnt in the previous lesson: ideal gases, equation of state, Gay Lussac's first law. After that, controlling questions (definitions, formulae) were asked and they were followed by an introduction, consisting in playing a video which presented a balloon competition.

The analysis of a video included: elevation/fall → the definition of physical phenomena and observing consistence and temperature change. The connecting question was: what would happen if we increased the temperature?



Picture 3. Picture of the board – Gay Lussac's second law.

The new lesson introduced Gay Lussac's second law. The students were taught in an inductive way. The teacher used animation to let students find out and formulate the law. The students were active during the lesson, they were deeply involved in the topic, since the animation showed the changes accompanying physical phenomena very well. Their interest was also verified by the number of questions they asked.

Calibration of IWB: Students became impatient because the special pen went dead. Students seem to rebel when something does not go well, so the teacher has to react very quickly to technical problems, and solve them.

The teacher used an animation to demonstrate and explain Gay Lussac's second law. It was a methodologically very well-developed lesson, coloured with lots of curiosities. There were videos taken from our everyday life to visualise physical phenomena to make them easier to understand and learn by the students.

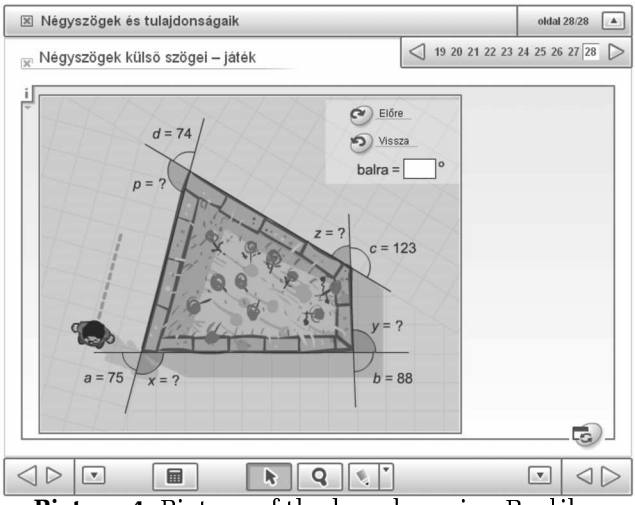
The teacher used a simulation of a physical experiment to make students discover and formulate the law. The interesting and sensible questions asked by students also demonstrated their keen interest.

Mathematics lesson in class IX.

The topic was Geometry, the title of the lesson was constructing quadrangles. The improved competence areas were: mathematic, digital and social competences, creativity, combinative skills, problem solving, and the development of thinking.

The aim of the lesson was to introduce the basic skills to construct a quadrangle, to make students become able to reproduce what they learned, to solve problems taken from the Realika digital database, and to use the IWB. The sole devices used were IWBs.

Learning organisation consisted in frontal work, individual work, and then common discussion, group work in the framework of a game.



Picture 4. Picture of the board – using Realika.

By using the interactive whiteboard, we could save a lot of time, and it was possible to practise more. The lessons started by revising general concepts; students could get acquainted with the characteristics of the quadrangle in an inductive way. Their knowledge was broadened starting from the special quadrangles towards the more general ones. The problems were taken from the Realika online database, and they were solved by students in groups.

Students quickly acquired the basic functions of the material and used them easily with the IWB. They were very interested in the loud explanations, animations and interactive tasks accompanying the material.

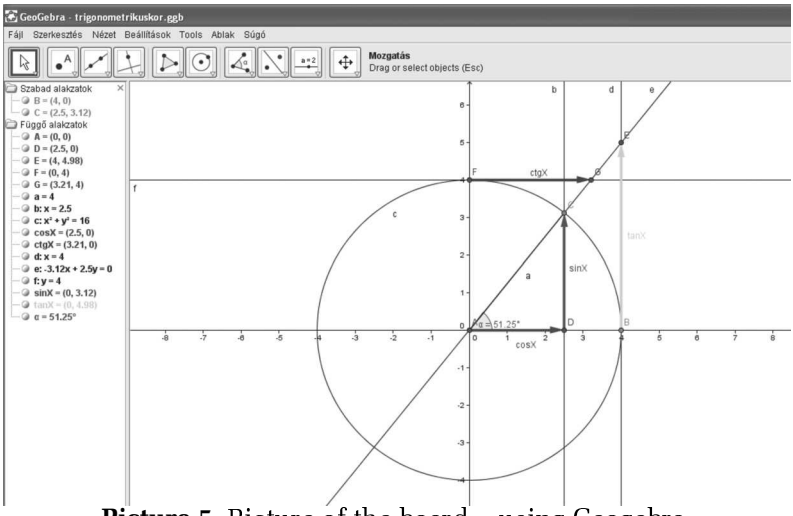
In the meantime, we also demonstrated the possibilities of constructing with the help of Geogebra, which was taken with great enthusiasm, since it is a very versatile and simple program.

Mathematics lesson in class XII.

Here the topic was Trigonometric, and the title of lesson was Rotation angles. The improved competence areas were: mathematic, digital and social competences, creativity, combinative skills, problem solving, and the development of thinking.

The aims of the lesson: constructing the trigonometric circle, plotting sin, cos, tg, ctg functions in a trigonometric circle, rotation angles, rotation, translation, reflection, dilation, using Geogebra and the IWB, and making students be able to plot a function.

The sole device used was IWB. Learning organisation included frontal work, individual work, and then common discussion, group work.



Picture 5. Picture of the board – using Geogebra.

It is important to highlight the constructing and modifying options of the diagrams made by the program Geogebra – diagrams which would be very difficult to do using traditional methods.

The program makes it possible to demonstrate more special or exceptional cases. The students also learned how to construct with the program very quickly. They were impressed by the possibility of animation. They practised their new knowledge individually and in groups, too.

Using Geogebra is recommended for primary and secondary school students, since it is quick and easy to construct mathematical shapes, and there is an algebraic

window where they can see the coordinates of the given points or equations of lines. This can help them understand the different representations of geometric shapes.

The students were really enthusiastic and wanted to download the program to be able to use it at home.

However, the amount of time used to prepare the digital material for the above two lessons is highly remarkable. Even with appropriate IT knowledge, it took at least 2 or 3 hours to put together and plan the methods, choose the pictures and dias, find the problems, construct the shape and search for curiosities on the internet.

The efforts were rewarded when the students were watching the board with sparkling eyes, asked questions and interactively took part in the lesson.

Using digital materials

While preparing the above lessons, the teacher may have the following three choices.

It is the easiest to use only ready-made digital material proposed by course book authors. Another possibility is to mix ready-made material with material or animations found on the internet and with their own self-made materials. The third choice is to use only your own material.

Among the teachers asked in the survey, the second choice was the most popular; teachers like adapting ready-made material to their students' needs.

If teachers want to make their own material for a lesson, they might refer to the following:

– SDT (Sulinet Digital Knowledgebase), electronic teaching equipment;
– Realika Digital Database;
– Digital materials on schools' or teachers' WebPages;
– Cooperation between teachers: teachers' communities (e.g. e-tanarikar);
– Multimedia CDs, DVDs, educational software, IT software, digital materials, e-books;
– Student-friendly e-contents;
– Electronic register;
– Virtual learning environment: Moodle, eLEMÉR, Quizlet.

Experience shows that it takes a lot of time and preparation to make digital material, but it is worth the invested time, because you can modify, extend and reuse the prepared material.

Questionnaires

Quantitative and qualitative methods were used to study teachers' and students' experience of IWB and using mathematical programs.

The qualitative data included case studies, lesson observations, interviews;

while the quantitative test consisted of questionnaires about students' attitude towards using IWB in mathematics lessons.

The conclusions in connection with the use of ICT devices, on the basis of lesson observations and making interviews in Ady Endre Secondary School, Debrecen, are listed in this paragraph.

The questions were the following:

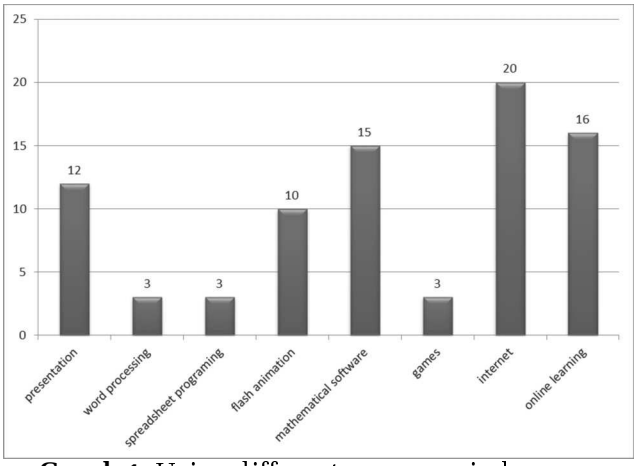
– How often do they use IWBs and ICT devices?

– What kind of positive and negative experiences do they have?

– What do students think about these devices?

In the meantime, a survey among students in some bilingual classes was made after giving them some lessons, where ICT devices were used. 21 questionnaires were sent back from the observed group, 12 of which were filled in by girls and 9 by boys.

Most of the students know and use some dynamic geometric program, and they have had the opportunity to try and use other programs as well at school. The personality of the teachers is thought to have a great influence on what programs their students know. The teacher controls the learning process at school, and the students start reading about and using certain mathematical programs on the teacher's advice.



Graph 1. Using different programs in lessons.

Graph 1. shows the frequency of the programs used in mathematics lessons. It must be remarked that it is a major advantage of the school that teachers have internet access in every classroom, and, as the following diagram indicates, they are fond of using it.

Among the students involved in the survey we can find people who look up further information in connection with the material in the lesson if they find it

interesting (20%). On the other hand, the material presented during the lesson is enough for 20% of the students, and they never search the net for further information. Another 60% of them state that they rarely take advantage of the possibilities of the internet. In the future, the number of students using the net to enrich their knowledge will increase. Sometimes students may gather more information in advance than the material presented by the teacher during the lesson. Some malicious students even use this information to test their teacher's knowledge.

In most cases, the students said that the teachers used the interactive whiteboard and, in a classroom where there was none, they try to use a computer and a projector to make the lesson more interesting. The students do not know what the voting system is, which may be due to the fact that they have not heard about it, or their school has not purchased any. In the second part of the questionnaire, the questions referred to the students' opinion about the new device, and we wanted to find out their ideas about the school of the future. Their answers were the following.

Question 1. referred to what students liked about using the IWB in math lessons. The most popular answers were the following:

– *The program presented was rather useful!*
– *I liked the multiple choice task on the internet!*
– *Lots of new and interesting information got presented! There was lots of new and interesting information!*
– *Wide use of IWB!*
– *Versatility of Geogebra!*
– *Using Geogebra!*
– *I liked the most, when we solved problems on the internet!*
– *We used the interactive whiteboard a lot!*
– *The experimenting tasks presented on a website!*
– *The mathematical programs!*
– *We did not waste time taking notes, I can look up everything we learnt on the website.*

The opinions above show that the students find the mathematical programs presented with the IWB very useful and interesting. The versatility of the programs impressed them, and they started asking how they could install them on their own computers at home to be able to experiment with them. This way they could playfully improve their mathematical knowledge at home. They liked the online quiz, because it also gave them opportunity to practise.

Question 2. referred to their negative opinions, i.e. what they did not like in the lessons. The most popular answers included:

– *When Gergő broke the special IWB pen!*
– *There were no traditional devices, which was strange!*
– *Sometimes the lesson was too fast and I could not understand it!*

– *When the IWB went wrong, it took a lot of time to fix it!*
– *Sometimes my attention was diverted, even if the IWB was used!*

The students remarked that the IWB is not always useful, it is not necessary to use it during the whole lesson, but they highlighted that it was very useful when they had to solve geometric problems: it was easier to prepare the diagrams with the help of the board and the software.

In the meantime, the failure of the device and the elimination of the problems are a waste of time. One of the above opinions denotes one of the most important mistakes teachers can make: students may lag behind and find it difficult to follow the material, when the teacher plans too much for a lesson.

In **Question 3.** the students were asked about using the ICT devices and their experience (with IWB, mathematical software). Their responses included:

– *I think it is a good thing, it makes work easier for teachers and students.*
– *I think it is a very interesting and useful device!*
– *I think they are useful because they help us understand things better!*
– *They are useful!*
– *I liked it very much, it makes the material easier to understand, and raises my attention more, so I pay more attention to the lesson!*
– *Quick and useful!*
– *Useful, it makes the acquisition of the material easier.*
– *It is good for the teachers because chalk does not dry their hands, and students learn more during the lesson, since connections are not only explained, but also showed.*
– *Useful and helpful!*
– *I find it very good, the lesson is more interesting this way!*
– *IWB is useful!*
– *Useful, I liked it very much!*
– *In most cases, it helps us understand the material!*
– *I find the IWB very good, because you do not have to inhale chalk powder, but preparing the presentations takes a lot of time. It is sometimes more visual, and there are a lot of useful things on the internet, but I think it has got both advantages and disadvantages.*

The above listed opinions show that a lot of students used the word 'useful,' so students could experience the benefits of the IWB compared to the traditional boards. It made the material easier to understand and learn, furthermore, it made students more motivated and interested in the lesson. However, some of them pointed out that ICT devices have drawbacks as well, especially when they are not used properly.

Question 4. referred to students' ideas about the future school. These were the following:

– *I am sure that they will use a lot of ICT devices at school!*

– *Modern, but they do not want to every subject through information technology.*
– *More modern! A lot of up-to-date ICT devices!*
– *There will be more ICT devices; maybe each student will have them. Possibly, students will learn through the internet!*
– *Only interactive devices will be used!*
– *Everyone will have a laptop, and students will get information through the internet, and they will write tests on it!*
– *IWB, electronic registers, internet, etc.*
– *I do not want the school to change, because I like it the way it is!*
– *Well equipped, but I do not really know!*
– *Full of ICT devices, with modern new things!*
– *Every student has got a laptop and they carry it to school instead of books and exercise books.*
– *Everything will be taught through the internet!*
– *More schools will have IWB!*

It is evident that the students would like to use more ICT devices in their education. They listed the equipment which they found useful. They want IWBs, laptops, modern up-to-date devices. In some schools, students do not have to wait long for these devices to arrive, since – with the help of different tenders – schools will get interactive whiteboards, computers, laptops, projectors and other supplements. It is the teachers' task to integrate the new devices into the lessons. It is a slow but continuous development through which teachers get acquainted with and find appropriate teaching methods.

Conclusions

With the use of ICT devices and different programs, the borders between different scientific areas are disappearing. It is easy to see that, together with their mathematic knowledge, students also improve their digital competences, furthermore, their artistic taste develops, too.

Using the device and the digital material lesson by lesson, they learn how to make an easy-to-follow presentation. So, while using ICT devices, students improve different competences, for example their digital, mathematical and social competence.

The growing digital or net generation needs the use of equipment; as we could see, their future ideas involve ICT devices, and they want them to be used in their education. The lessons are renewed, the teaching methods are changed, and the teachers' role becomes different: teachers will be helpers, and they will supervise and manage the lessons.

There will be more opportunities for group work, cooperation between students

and teachers, interactivity, dynamism, creativity, feedback, and, most importantly, motivation, gaining and keeping students' interest.

Besides the above advantages, the most important aim of using mathematical programs and IWB is to help students in learning.

It is supported by several international researches: it was determined that students' attitudes towards the use of IWB in mathematics classes are at a medium level, and that students see the IWB as a tool that increases their interest and facilitates learning (Tataroglu and Ayten 2010).

The IWB is not a wonder device. It can make the lesson more interesting, attractive and useful only if the teacher uses it with adequate knowledge of methodology.

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