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# Integrating STEM-related Technologies into Mathematics Education at a Large Scale

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*This paper outlines the growing phenomenon and need to integrate technologies into mathematics and science teaching and learning. There are a number of successful projects for valuable integration of technologies around the world, however, these successes are often limited reaching a relatively small number of teachers and students. In this paper, we aim to offer examples of large-scale technology projects that could create a critical mass of users that could further drive innovation and sustainability for educational technology integration. We outline how GeoGebra became one of the most widely used dynamic mathematics software with a user base of more than 100 million; highlight directions of research for technology development and integration; and describe the Geomatech project that aimed to train 2500 teachers in 950 schools in Hungary. We hope that such examples, the developed technology, resources and pedagogies could contribute to further valuable integrations of technologies in mathematics and science education.*

## 1. INTRODUCTION

There is increasing consensus among mathematics educators and mathematicians that technology is ultimately becoming an integral part of mathematics teaching and learning, affording new forms of dynamic representations and communication (e.g., Heid & Blume, 2008; Lavicza, 2010). New mathematics learning technologies can provide multiple representational resources and linking mechanisms that support students' exploration of complex mathematical ideas and structures in a dynamic manner (e.g., Moreno-Armella, Hegedus, & Kaput, 2008). Furthermore, through "thought-revealing activities" (Kelly, Lesh, & Baek, 2008), these rich and interconnected representations have the potential to enhance students' mathematical experiences and foster deep understanding of mathematical concepts (Kaput, Hegedus, & Lesh, 2007). Despite the opportunities that technologies could offer and the enormous investment into classroom technologies and personal devices the deployment of technology-assisted learning in school-based education has been marginal (e.g., Drijvers et al., 2010. There is little evidence for educational system-wide impact of technologies on learning improvements and less than 10% of teachers use some kind of technology in their mathematics teaching (e.g., OECD, 2009). However, studies showed that there are a number of local initiatives of innovative teachers who really make an impact on students' learning (e.g., Drijvers et al., 2010; Lavicza, 2010; Jarvis, Lavicza & Buteau, 2014).

Successful integrations of technology into mathematics education depends on several factors, but most studies suggest that teachers' preparations, various beliefs, and freedom and alternatives to use technologies are important (e.g., Drijvers et al., 2010, Jarvis et al., 2014). There are large-scale projects where millions of laptops or tablets are distributed to students, for example in Argentina, Thailand, Uruguay, USA etc., but studies show that for the majority of teachers, solely providing technology is insufficient for the successful integration of these new tools into their teaching (Weigand & Bichler, 2010). It has been suggested that adequate training and collegial support boost teachers' willingness to integrate technology into their teaching and to develop successful technology-assisted teaching practices (Clements, 2007; Drijvers et al., 2010). For teachers to integrate new mathematics learning tools into their daily practice, it is critical that they understand the affordances, constraints, and general pedagogical nature of such new representational resources in relation to the specific mathematical topics of school mathematics (Hennessy, Ruthven, & Brindley, 2005). Another important factor of integration is the beliefs about and attitudes towards technology by teachers. If they are convinced by its usefulness then they use it more successfully in their classes and that strongly correlates with students' beliefs and attitudes and could promote higher achievements (Lavicza, 2010). Furthermore, although training teachers for using technologies is crucial, offering them only narrow opportunities of uses could be counterproductive (Lavicza, 2010). Rather preparations of teachers should offer a range of possible technology integration opportunities and they should be able to suit these methods to their own teaching style and practices (e.g., Laborde, 2001; Lavicza et al., 2010). Finally, it is shown that technology integration is usually initiated by some

innovative teachers, and its sustainability and spread to other teachers' practices really depends on the enthusiasm of such key people (Hohenwarter, Jarvis, & Lavicza, 2009; Jarvis et al., 2014). During the past decade, we have been working on developing research projects to further enhance technology integration into education as well as to increase the uptake of digital technologies in classrooms around the world. To be able to ensure its wider impact, with Markus Hohenwarter, the creator of the GeoGebra software, and other colleagues, we developed a world-wide network of GeoGebra users and developers and formed the International GeoGebra Institute (IGI) to offer a forum for these participants.

Before further discussing the importance of IGI in enhancing the uptake of technology integration, we will first introduce the GeoGebra software. GeoGebra, the open-source mathematical software, created an opportunity to offer free access to a high-quality mathematical tool that generated a large user community (100 million+ users, 153 GeoGebra Institutes, 1 million+ shared examples), spread by enthusiastic teachers who offer examples and training to their peers (& Lavicza, 2009; 2011). GeoGebra was designed to combine arithmetic, algebra, geometry, calculus, statistics and more recently support to STEM subjects in a single, integrated system available at most technology platforms and offered free to teachers and students in all regions of the world. GeoGebra was originally created to connect algebra and geometry into a single platform (Figure 1), but now due to its quick development it is employed in most mathematical subjects integrating new technologies such as Augmented and Virtual Reality, 3D Printing and mobile learning.

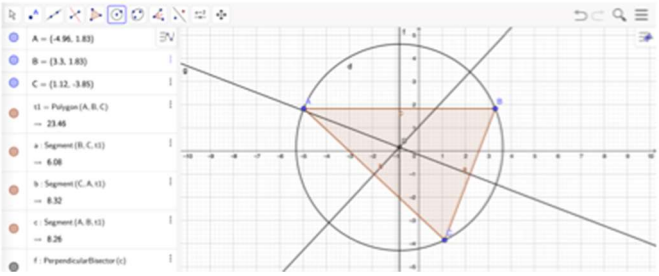

Figure 1 GeoGebra Classic layout. Connecting geometry and algebra

Thus, given the open-source nature, web-accessibility, and the growing international user community, GeoGebra is not only high-quality software but also economically sustainable in empowering classroom teachers to support all students in learning significant mathematics and science (Hohenwarter, Jarvis, & Lavicza, 2009).

The GeoGebra community and the network of 153 GeoGebra Institutes enabled us to observe the trial of GeoGebra in numerous classrooms around the world. Moreover, the community supported teaching and learning materials that could be readily utilised by teachers and students in their own countries. Members of the community have already shared more than a million learning objects on the GeoGebra Materials platform (Figure 2) and translated the software and related documentation to 62 languages. It can be seen that building this large community has supported the acceptance of the technology in classrooms, but we felt that this is only the beginning and various research needs to be carried out in this area to be able to further develop technology integration. Therefore, we proposed and participated in a range of research projects that examined different aspects of technology uptake. Building on the results of such projects we proposed a large-scale project in Hungary to experiment with a large-scale integration of technology within an education system. In this paper, we outline some results of such projects and introduce the work of Geomatech and their implications.

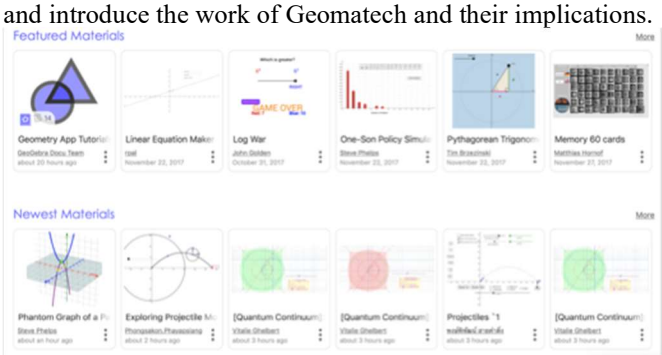


Figure 2 GeoGebra files uploaded to GeoGebra Materials platform

## 2. EXAMPLES OF TECHNOLOGY-RELATED PROJECTS CONTRIBUTING TO GEOMATECH

During the past decade members of our group have participated in numerous projects to advance technology integration and related pedagogies into mathematics teaching and we outlined some projects that backed the development of the Geomatech project. Furthermore, the experience from coordinating projects at the International GeoGebra Institute (IGI) added to this work. An international study examined mathematicians' views on the importance of technology in mathematics education and their practices in university-level teaching in three countries, US, UK and Hungary (Lavicza, 2010). In this study, based on more than 20 in-depth interviews and questionnaire responses of 1100 university mathematicians, colleagues stressed the importance of technology integration into mathematics learning and teaching and highlighted that students must be literate in various technology resources. It also appeared that mathematicians had a more extensive use of technology than teachers, but little was known about their uses, as there were no studies reporting on these issues (Lavicza, 2010). Furthermore, the study found that mathematicians would prefer their students arrived at university with substantial mathematics-related technology knowledge so they could build on this basic knowledge. Later, this study was extended to Canada, where a similar survey was carried out confirming the need for technology integration both at the university and the school level (e.g., Jarvis et al., 2014). Moreover, we carried out a study to explore the sustainability of technology integration in mathematics departments in Canada and UK (Jarvis et al., 2015). It became evident that devotion by both teachers within school departments as well as departmental leaders and the administration play an important role in well-developed and sustainable technology-enhanced programmes. The vision and devotion to technology programmes are essential to

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sustain programmes, but generating a critical mass of teachers, with available training and resources, is also necessary for sustained integration (Jarvis et al., 2015). Research at the university level, together with our experiences in the GeoGebra community, highlighted the need for examining various aspects of school-level technology integration. Later, we ran several projects both in Europe and USA, which laid the foundations of teachers' professional development with technology, as well as establishing the International GeoGebra Institute to enhance teacher support, material development and research around the world (e.g., Hohenwarter et al., 2010). It became evident that teacher professional development is key for successful technology integration and through the support of the National Centre for the Excellence of Mathematics Teaching in the UK, we carried out a study in Cambridge to gauge how technology integration fits into the English curriculum, how teachers integrate technology into their work, and what resources and training they envision to ease their work. We worked with nine teachers for more than a year utilising Design Experiments (Cobb et al., 2003) and Communities of Practice (Jaworski, 2006) frameworks, to designed resources and professional development for English teachers (e.g., Lavicza et al., 2010). Besides developing and matching technology-resources to the curriculum and carrying out professional development activities, we found that technology integration is slower than expected in the past. This was in line with other similar studies, for example Laborde's (2001) important longitudinal study highlighted similar issues. The study also stressed an important pattern showing that most teachers begin the use of technology by presenting projected dynamic materials in their classes and become familiar with technology use in such a way. When teachers' familiarity increases, they allow students to have more interaction with the materials, and finally let students design and manipulate their own materials (Figure 3).

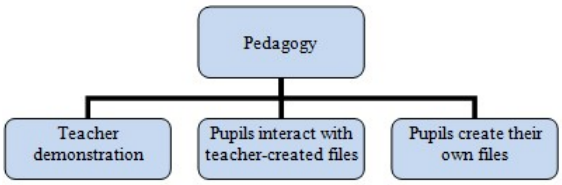


Figure 3 Teachers introducing technology into their practice (Lavicza et al., 2010)

This sequence was not only about becoming familiar with technology, it also changed the role of the teacher and the power-relation between the students and teachers in the classroom. As teachers allow more freedom for students to work on technology materials, students become more autonomous and the lesson might go to a different direction than planned by the teacher. Thus, the role of teacher in the class slowly changes to become an orchestrator of the lesson rather than someone who transmits knowledge to student. The dynamics of lessons substantially change, making new opportunities for students to learn, at the same time posing additional challenges for teachers and requiring substantial preparation from the teacher to successfully act in such a new environment. This role change was observed and analysed by the Instrumental Orchestration Framework utilised by a number of researchers and described in detail in for example Drijvers et al. (2010) or Ruthven (2014). However, the increased demand on teachers would necessitate additional training and resources to successfully operate in such a new environment (Lavicza et al., 2010). In addition to the new demands faced by teachers in technology integration, the environment is also rapidly changing, making their work even more challenging. For example, the emergence of touch technologies has begun to alter the way how computers are used and what kinds of teaching materials can be designed to enhance successful uses in education. The rapid spread of tablets, mobile phones and Interactive Whiteboards has already begun altering the way teachers design and use them in their lessons (e.g., Lavicza & Papp-Varga, 2010). In the following section, we will outline some challenges educators face due to the rapid changes of technology and the educational environment of our age.

## 3. NEW CHALLENGES IN MATHEMATICS EDUCATION RESEARCH IN THE 21ST CENTURY

As explained earlier, technologies are becoming an integral part of everyday life and slowly shaping mathematics and science teaching and learning. Although there have been enormous investments in educational technologies in many countries, technology has yet to make a sizable impact on education. On the one hand students are becoming increasingly proficient users of technology, while on the other hand opportunities offered by technologies have still little been utilized. Here, some new challenges connected to accessibility, collaboration and experimentation will be highlighted to call for research in these areas, as small contributions to the field would enable further progress based on knowledge and evidence.

### 3.1 Accessibility

In the 1980s and 1990s, it was predicted that technologies would quickly penetrate education, especially in mathematics and science classes (e.g., Steen, 1988). At that time, accessibility to computers was scarce and it was predicted that increased accessibility would greatly increase the uptake of computers uses in classrooms. However, soon it was apparent that accessibility alone would not increase technology uptake, but there were more complex issues to be considered. Changing practices and conceptions of teachers, offering new resources and opportunities for computer use, and particularly developing new pedagogies and teacher professional development became important issues for researchers (e.g., Lavicza, 2010). Furthermore, not only accessibility improved in many countries, but large-scale technology resources distributing millions of laptops and/or tablets are being imposed onto education systems such as through the One Laptop per Child project, Connectar Igueldad in Argentina, and Plan Ceibal in Uruguay among others. In addition to the increasing availability of resources, technology is rapidly changing. For example, when GeoGebra was developed in 2001 only computers or calculators were used in classrooms, but with the emergence of smart phones and tablets the field is changing together with the design of materials and pedagogies. Learning from these we developed mobile

platforms and experimenting with their uses in classrooms. Nevertheless, it would be important to investigate many aspects of technology use in such a changing environment with new availabilities and technologies emerging.

### 3.2 Collaboration

Technology is also changing communication in society and it has an effect on classroom practices and beyond the classroom as well. Earlier, we mostly referred to collaboration among students and thought of group or project work. It is still important and we will discuss it further later, but we need to consider collaborative environments offered by the Internet. GeoGebra has quickly become one of the most widely used mathematical applications because its community was organised on the Internet and ideas and resources are continuously being shared on the GeoGebra Materials platform offering hundreds of thousands available ideas. Social media also became a new phenomenon on the Internet posing difficulties as well as ample opportunities for education. Allowing the use of, for instance, Facebook for education is troubling for many schools and educational systems, but there are opportunities to be harvested through this popular student tool. Learning management systems such as Moodle and Blackboard are becoming mainstream in education, but still there is increased demand to evaluate their effects on education. Collaboration has existed mostly in classrooms, but because of the Internet there is an extensive need to develop multiuser environments so that students could continue collaboration beyond classroom groupwork. Possibly, one of the most interesting changes of our age is that digital collaboration and tools have led to the revised design and use of textbooks. There are already numerous initiatives for developing digital textbooks, but we believe that we are still in the beginning of this revolution. In contrast to paper-based textbooks, digital resources would allow flexible arrangements and distribution of learning materials. In particular, there is an opportunity that rather than having a single or limited number textbooks for all students, each class, or even each student, could have a personalised textbook for essentially no additional cost. Thus, the GeoGebra team started experimenting with a new generation of textbooks, but it is needless to say that the education community is only at the beginning of such change and the forefront of thinking lies ahead of us.

### 3.3 Experimentation

Experimentation has been an important element of mathematics teaching and learning and curriculum reforms have usually promoted connections with real world problems, data collection, analyses, and students' projects. Inquiry based education (IBE) is becoming an increasingly important element of developing new curricula and pedagogical approaches (Artigue and Blomhoj, 2013) and heavily emphasizes the experimental dimension of mathematics education. Technologies offer new opportunities for experimentation, even mathematicians stated that they use technology because in this way they can more easily treat students as mathematicians and nurture their knowledge through discovery and experimentation (Lavicza, 2010). Nevertheless, while experimentation could involve technologies, manipulating physical objects should remain in perspective for such considerations. Combining physical and technology experimentation or even creating virtual environments could become an even more interesting approach to improve mathematics and science education. For example, the Experimental Workshop Movement develops exciting ideas to connect not only Arts with Mathematics and Science, but also physical and technological experimentation, making the tools available for public education and organising workshops and fairs for thousands of students and teachers (e.g., Fenyvesi, 2012)

We believe that we should go further when considering experimentation. Often, teachers are reluctant to use technology in their own teaching because they are not experienced and their students have more extensive knowledge of using digital tools than they are. Moreover, students grew up with technology and have very different views on technology than teachers. There are some brave attempts by some universities in for example India, who allow young students to train teachers to use technology. It seems to be an interesting initiative and could further our understanding and progress in technology use.

The list above only offered a brief list of topics that need to be researched to be able to prepare for upcoming uses of technology in education. There are numerous research projects working on various aspects of technology integration, but because of the extent of this area, more attention and resources need to be supplied. It is not only important that experiences researchers work on this area, but also it would be crucial to encourage young researchers working on their theses or PhD dissertations to engage in such research. International contributions and comparisons, which are well coordinated, could contribute to our understanding considerably.

### 3.4 The Geomatech Project

Building on the above described research projects and the ideas to be considered for technology-related mathematics education we decided to develop a project that could integrate already developed ideas, a range of theoretical approaches, and scale initiatives up to produce a sustainable work. With the support of the European Union and the Hungarian Development Agency, we received substantial funding to develop the Geomatech project in Hungary to enhance technology integration in schools. Previous technology education projects were carried out in a small scale and after completing the project they failed to sustain or scale up. Geomatech is unique in this aspect, because we work with approximately one-third of the schools in Hungary (800) and a large number of teachers (2400), hoping that reaching a critical mass of schools and teachers will help to sustain and further develop results of the project. In this section, we will outline the main targets of Geomatech and explain how it could contribute to technology education in general as well as how we plan to extend the reach of this project in other countries.

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In Geomatech, we agreed on the development of high quality mathematics materials (1200) and science resources (600) that incorporate ideas from other projects/initiatives and from the GeoGebra Community (Korenova et al., 2018). Furthermore, it is highly important to offer pedagogical recommendations to teachers who will use these materials in their classrooms. The research team of Geomatech reviewed materials from a large number of websites and tens of thousands of GeoGebra worksheets from GeoGebraTube and developed a database for material development. Together with these resources and the ideas of the Geomatech team (we worked with close to 300 colleagues representing many universities in Hungary and abroad as well as a wide range of schools), we developed the required materials. The development not only included the review of mathematical ideas, but review of design for didactical considerations.

For pedagogical considerations, we were in a fortunate position, as mathematics and science education in Hungary have a high respect all around the world. There have been numerous great mathematicians and scientists winning Nobel, Wolf, Abel and Kyoto prizes contributing to and even establishing new fields and areas of research. Similarly, Hungarian mathematics education theorists and practitioners-- among them George Polya, Zoltan Dienes, Imre Lakatos, Tamas Varga - are often quoted as great innovators and founders of modern theories and practices in mathematics and science education. Furthermore, Hungarian young scientists have been topping the winners of mathematics and science Olympiads for decades (e.g., Andrews, 2003; Andrews and Mantecón, 2015).

The teaching and learning approaches that are reviewed and now utilised in many countries in education reforms have in many ways common roots that Hungarian traditions offer. Looking back on the success of the "Magyar modszer" could really help us to train not only the best mathematical minds in Hungary but also can be extended to more general education as well. In the 1960s and 1970s, Tamas Varga conducted and directed a series of experiments in primary schools that led to the "Complex Mathematics Education" (CME) reform program, which was introduced in 1978 in Hungary, with long lasting effects on mathematics teaching and learning (Gosztonyi, 2013). However, the introduction of this reform was only successful in schools that were ready to embrace the ideas of the "Magyar modszer" (Gosztonyi, 2013). Nonetheless, the schools that were not ready to embrace these ideas fell behind. In Geomatech, we attempt to update these ideas and combine them with technological approaches. Additionally, we also connect traditions to related current theoretical approaches such as Inquiry Based Education (IBE) and Programme for Complex Instruction (PCI).

In the past decade, IBE is becoming an increasingly important element of developing new curricula and pedagogical approaches. Artigue and Blomhoj (2013) summarised and conceptualised the theories and initiatives behind inquiry-based education. They reached back to the early 20th Century ideas of the American Educational Philosopher John Dewey from whom ideas of IBE are derived, stating that: "education should be for all, stimulate students' interest for learning and cultivate their autonomy, aim at the formation of human beings able to play an active role in the development of societies, and reject traditional teaching practices focusing on instruction and drill" (Artigue & Blomhoj, 2013, p. 2.). This important review article examined theories and six frameworks[1] both for inquiry-based mathematics education (IBME) and inquiry-based science education (IBSE), which are both relevant for the Geomatech project.

It is interesting to observe that many of the recent initiatives for enhancing mathematics and science education around the world have surprisingly common elements with the Tamas Varga mathematics reform movement in the 1960s. The Programme for Complex Instruction was developed at Stanford University and later adopted by Kovácsné Emese Nagy in Hungary, with great success in disadvantaged schools in Hungary. The PCI programme encompasses cooperative learning methods and demands from both teachers and students to take responsibilities in their own and their groups' work and success. At the same time, all students are becoming competent, active, and equal members of the group while realising that everyone can contribute some special skills to the learning process. PCI has three major elements: 1) curriculum for a variety of student skills; 2) special guidance for teachers and teaching; and 3) distributed roles within and across learning groups. The programme also employs project-based learning, games and simulations, and case study investigations.

Since the first introduction of PCI in a Hungarian Primary school, where more than 90% of students come from disadvantaged and minority background, the school, initially one of the lowest achieving institutions in the county became one of the highest performing ones. This approach was important for Geomatech as we worked with close to 100 disadvantaged schools in Hungary.

In sum, the material development part of Geomatech incorporated a wide range of traditions and new theoretical and practical frameworks to enable the high quality of the developed items as well as to use these frameworks in other parts of the project.

### 3.5 Software Development and Resources

Mobile phone and tablet technologies have been developing quickly during the past years. They are getting even more accessible for students and teachers both at home and in the classroom. Therefore, we developed experiments that utilise the wide range of sensors built in mobile devices. For example, Figure 4 demonstrates the acceleration sensor.

1 1) the problem-solving tradition; 2) the theory of didactical situations; 3) the realistic mathematics education programme; 4) the mathematical modelling perspective; 5) the anthropological theory of didactics; 6) the dialogical and critical approach to mathematics education.

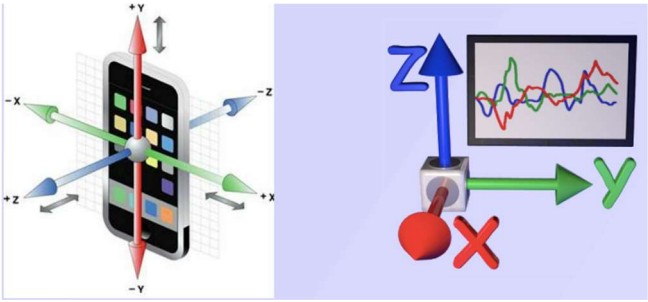


Figure 4 The acceleration sensor in mobile phones or tablets built in mobile phones

Utilising the acceleration sensor, we can easily set up experiments to measure the friction between the phone and a surface on which it is being slid. Thus, we can collect actual data and analyse it within a computer environment such as GeoGebra. But, within GeoGebra it is not only possible to analyse the actual data set, but it is also possible to set up virtual model in parallel to the experimental data to demonstrate a wide range of physical and mathematical concepts (Figure 5).

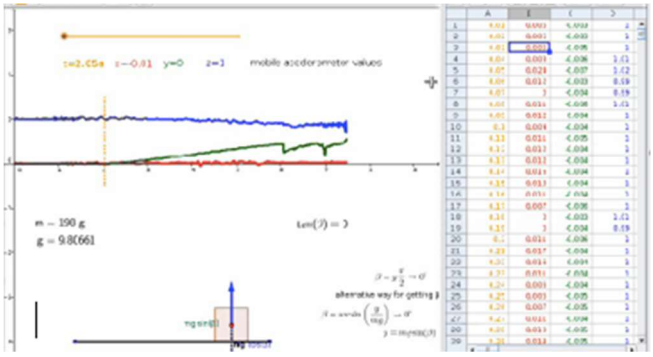

Figure 5 Data capture, analysis and virtual model from a sliding phone experiment

Experimentation and capturing actual data are powerful ways to raise students' attention and improve their understanding. But it is also promising that data could be captured from a range of mobile phones and then collected by the teacher for analysis or, in reverse, the teacher collects experimental data and broadcasts them to students.

Furthermore, collecting sensor data and connecting it to real-life video broadcasts can even have a motivating effect on students' learning. Shooting short videos could be also an important way to motivate students and carry out interesting experiments within and beyond the classroom. We made GeoGebra capable to connect with video analysis software. Data capture from mobile phones and broadcasting data to students with analysis (Figure 6). In the same way, we can involve students in design models that can be motivated with real-life pictures or videos and they can better understand the mathematical background of such systems (Figure 7).

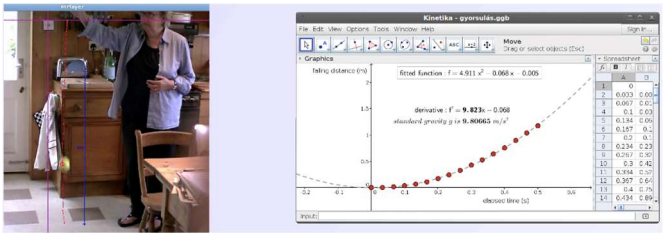

Figure 6 Video experiment Tracker connected with GeoGebra

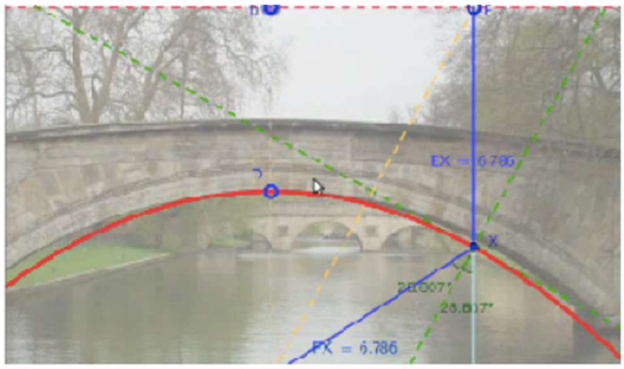

Figure 7 Modelling bridge arcs

Game-based learning has also a powerful effect on students' learning and motivation, as suggested by the theoretical frameworks described earlier. We made changes in GeoGebra to be able to develop games for students to understand basic concepts. It is important for younger students, who already have extensive experience with computer games, to be able to work with examples that integrate different topics. Figure 8 demonstrates a multiplication game that students are eager to play. Similarly, practicing different concepts in a game-based environment could contribute to students' mastery of mathematical concepts. Their responses are shown in the coordinate system and the fox chasing the bunny gives them additional motivation for right answers.

Finally, the software development part of Geomatech involves a portal that incorporates and structures the learning objects that teachers and students can easily use. Additionally, it will offer the opportunity for teachers to create virtual classrooms, assign activities for classes and homework, and follow the development of students.

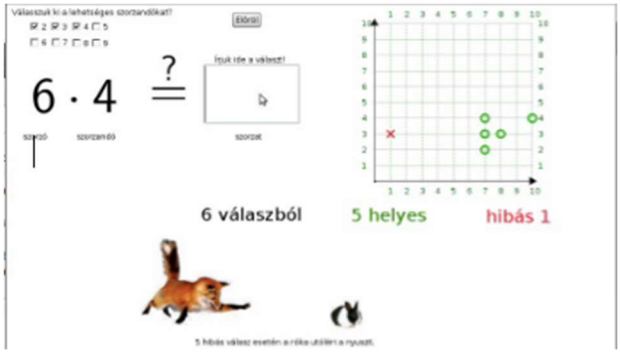


Figure 8 Multiplication game in GeoGebra

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### 3.6 Piloting Resources and Software

Geomatech has a strong research component that offers not only theoretical contributions to the field, but also immediate feedback for material and software development as well as teacher training. We ran a pre-pilot study in two schools trialling the framework of Lavicza et al. (2010) and collected observation and interview data for the pilot study of Geomatech. The analysis of this work is reported in Prodromou, Lavicza & Koren (2015), Prodromou & Lavicza (2017) offering valuable contributions to the design of the pilot. The pilot study of Geomatech utilises Design Experimental (DE) methodology, which is becoming one of the most powerful research methodologies in empirical education research. DEs are combining research methodologies such as developmental research, design research, and teaching experiments (Cobb et al., 2003). It involved teaching cycles, jointly developed by teachers and researchers, following a hypothetical learning trajectory, multifaceted data collection methods, and classroom-based analysis (Cobb et al., 2003). In essence, design experiments are methodologically aligned with the iterative nature of curricular research (Clements, 2007) and the spiral-like growth of teacher's technological content knowledge (Koehler & Mishra, 2009). Further, design experiments bring to the fore the teachers' classroom practice and children's diverse ways of mathematical thinking. We also utilise Barbara Jaworski's (2006) theoretical conception of communities of inquiry grounded in decades of her investigation into the complex problem of mathematics teacher education. Having teachers as members of the teaching community and part of the research group further enabled them to initiate inquiry-based learning in their classrooms.

### 3.7 Teacher Training

The teacher training part was one of the most challenging elements of the project from the logistical point of view. Our aim was to offer 60 hours of teaching for 2400 teachers in 800 schools in all regions in Hungary. It was an important criterion to include disadvantaged regions and select schools and teachers from these areas. The team is developed the content of the teacher development materials based on the pedagogical frameworks described in the material development part of this paper. Then, we organised schools within regions and teams of teacher trainers carried out the trainings in the selected schools. In the preparation, we were fortunate to receive a large number of applications and our numbers are already oversubscribed. Eventually, we extended the project to 950 schools and involved 2500 teachers in a different way in the project. In further papers will outline practise and results of the different parts of the project.

### 3.8 Student Competitions and Workshops

In Geomatech, we also organised various events for both teachers and students. The major activities were competitions. We advertised competitions in school and received in average 220 team applications involving close to 1000 students at rounds. Results of these completions will be reported in other publications. Beyond competitions, student teaching fairs are to be organised by the project, but the exact elements of these events depend on the other parts of the project.

### 3.9 School Network and Teacher Community

Most previous projects failed to be sustainable because of the lack of community and the continuity of innovations. Therefore, we aim to organise a school network and a teacher community in Hungary to keep results of the project alive. Currently, there are more than 300 still using Geomatech materials and more than 2 million applets were downloaded from the website in a year. We envisioned that approximately 10% of the schools and teachers remain active after the completion of the project and this number could offer a critical amount that would encourage other teachers and schools to be involved further. As with events, the ideas for these networks are under development and we are reviewing the organisation of other such networks and learning from the successes of the GeoGebra community.

## 4. SUMMARY

In this paper, we outlined the inevitable integration of technology in education. This integration is slow, but continuous. There are already large networks such as the GeoGebra community that are encouraging teachers and students to use technology in their teaching and learning. Also, there are large nationwide projects such as Connectar Igueldad and Plan Ceibal that offer technology resources for education into the entire education system. These initiatives are important to make progress, but it was highlighted that research is a crucial part to better understand elements of technology integration and even small projects could contribute to the progress in this area. However, we need to remember to involve previous research and develop new projects taking into consideration what was learned from past projects. Although small projects could contribute to our understanding of technology use in education, scaling up projects could offer new challenges for educators. Thus, large-scale projects are also necessary to explore nationwide initiatives. The Geomatech project is one such large-scale initiative, building on previous experiments and frameworks and attempts to develop new important knowledge and resources for technology-enhanced education. A number of researchers have already visited Budapest to look at what we are doing in the Geomatech project and they aim to develop similar projects in their countries. Adopting resources from Geomatech and training teachers could contribute to the local technology initiatives as well offering opportunities for international comparative studies and training of doctoral students from the data collected.

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