

Integrating GeoGebra into IWB-equipped teaching environments: preliminary results

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The aims of the project described in this paper are threefold. Firstly, we aim to examine how GeoGebra, an open-source dynamic mathematics software application, can be used successfully for mathematics teaching in Interactive Whiteboard (IWB)-equipped teaching environments. Secondly, we intend to uncover how professional development programmes could be developed and improved for the joint use of GeoGebra and IWB. Thirdly, we aspire to identify additional software features that would make GeoGebra more suitable for IWB environments. During the past year several workshops about the use of GeoGebra with IWB were offered for teachers and teacher educators in schools and conferences in Hungary. Participant feedback and comments were collected at these events and training materials have been continuously improved. This paper reports on the preliminary data analysis from the first round of the project highlighting participants' recommendations for improving both software features and professional development workshops.

Keywords: technology, interactive whiteboard, mathematics, GeoGebra, integration

Introduction and context

The integration of technology applications into mathematics teaching and learning has attracted immense attention from both the mathematics education community and from policy makers (Lavicza, 2008). Rapid advancements in technology and substantial investment into technology resources have greatly extended the variety of available technologies to be used in classrooms, but at the same time increased the pedagogical complexity for teachers (Ruthven, 2007). In spite of the early optimism in the 1980s about the rapid uptake of technology in mathematics classrooms (Kaput, 1992) and the recently increased availability, the use of technology in mathematics is still marginal in most countries (Gonzales et al., 2004). In addition, due to the development of projection technologies, the classroom dynamics were further altered from predominantly individual or group to shared classroom activities (Ruthven, 2007). More recently, the spread of interactive whiteboards (IWBs) has led to additional pedagogical challenges and

opportunities for the classroom use of technologies (Miller, Averis, Door, & Glover, 2004).

Mathematical software packages have greatly evolved during the past decades. Dynamic Geometry or Dynamic Mathematics Software (DGS/DMS) (e.g. Cabri Geometry, Geometer's Sketchpad, GeoGebra) packages gained an important place in school-level mathematics education due to their easy-to-use and directly manipulative interfaces. Ruthven, Hennessy, and Deaney (2008) explained that the design of DGS software has inherent a so-called interpretive flexibility and their mathematical potential of dynamic manipulation is recognised. A large number of studies have examined the potential of DMS in mathematics teaching learning (e.g. Laborde, 2001; Ruthven et al., 2008), but few have studied the potential and suitability of DMS in IWB environments.

In Hungary, a large-scale government initiative has seen most schools receiving IWBs during the past 4 years. Professional development programmes for general IWB use were also available, but subject-specific IWB training, particularly with other mathematical software packages, has rarely been offered (Papp-Varga, in press). In this paper, we outline a project that aims to assist in the integration of a specific mathematical software package: GeoGebra into IWB-equipped classrooms. In particular, the project has three aims:

- 1) to examine how GeoGebra can be successfully used for mathematics teaching in IWB-equipped teaching environments;
- 2) to uncover how professional development programmes could be developed and improved for the joint use of GeoGebra and IWB;
- 3) to identify additional software features that would make GeoGebra more suitable for IWB environments.

GeoGebra and IWB

We chose GeoGebra as the software to be utilised in the study for several reasons. First of all, GeoGebra is a free, multi-platform, open-source dynamic mathematics software. Thus, because of its open-source nature there are no licensing issues associated with its use, plus students and teachers are free to use it both within the classroom and at home. More importantly, suggestions for software changes from this project could be quickly integrated into new versions of GeoGebra. Secondly, GeoGebra combines dynamic geometry, algebra, calculus, and spreadsheet features (which other packages treat separately) into a single easy-to-use package making it suitable for learning and teaching mathematics from elementary through university level (Hohenwarter, Jarvis, & Lavicza, 2009). Figure 1 shows the interface of the GeoGebra software.

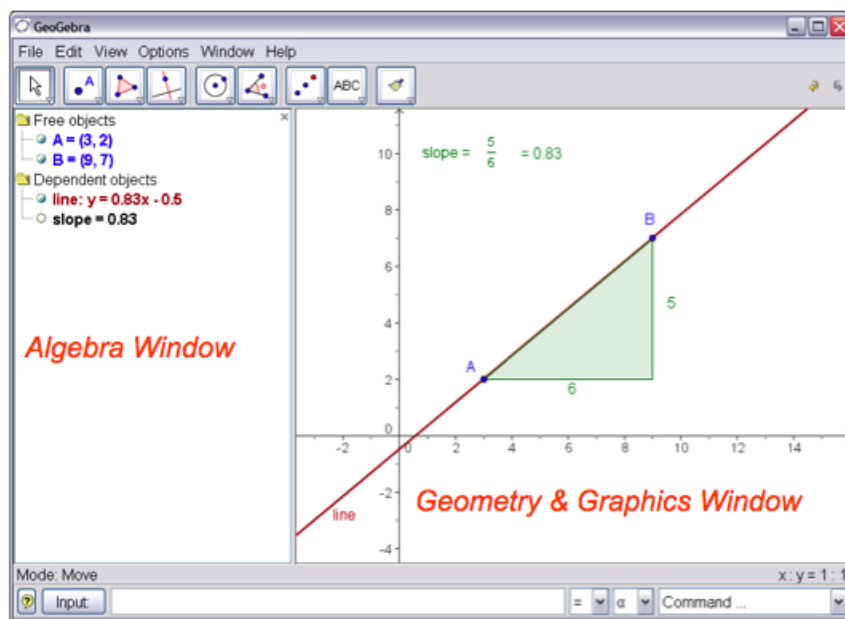


Figure 1: GeoGebra interface

Thirdly, GeoGebra has a large international user and developer community with users from 190 countries. The software is currently translated into 50 languages and attracts close to 300,000 downloads per month (Hohenwarter & Lavicza, 2009).

Methods

The interactive nature of GeoGebra lends itself naturally into its use in IWB environments. However, such environments differ from projector-based or computer-lab settings and necessitate new pedagogical approaches and even software alterations. Thus, several GeoGebra-IWB workshops were offered in schools and conferences during the preceding year in Hungary.

Based on participants' feedback and comments, training materials and approaches were continuously improved, utilising, though not strictly following, the theoretical framework of design experiments (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003).

The data collected included a short on-line questionnaire (67 responses) and eight interviews with participating secondary school teachers about their actual use and perceptions of GeoGebra use in IWB environments. Following the analysis of this data, lessons by participating teachers are currently being video-recorded and further interviews are to be conducted with teachers and students to better understand the classroom use of GeoGebra with IWBs. In this paper, we report preliminary results from the questionnaire and initial interview data. Results of the video study will be reported in future publications.

Workshop design and evaluation

Six workshops were offered for Hungarian teachers, three at teacher conferences, and three in schools. As many participating teachers were new to the use of GeoGebra and/or IWBs, an introduction to both environments was offered. However, the focus of the workshops was to provide training of the technology through mathematical problems. Participants of the workshops were a mixture of primary and secondary school teachers; hence we prepared a set of problems that was relevant for both groups.

For example, the problem in Figure 2 asked students (in this case teacher participants) to draw the symmetry lines of the objects on the screen. These symmetries could be drawn free-hand by pen on the IWB, but the line or segment tool of GeoGebra could be also used to increase precision.

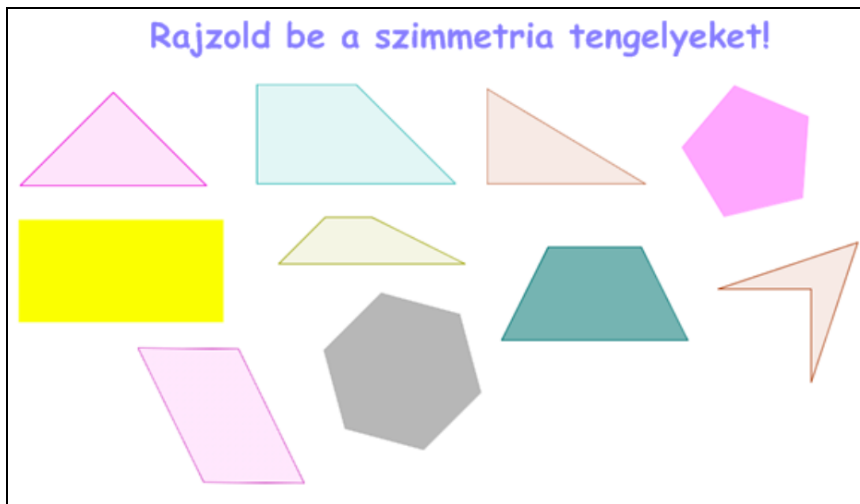


Figure 2: Finding symmetry lines

For secondary school teachers an investigation worksheet illustrated the relationship between the extreme points of a function and its derivative function (Figure 3). To find solutions both the drawing tools of the IWB and GeoGebra were applied to highlight relationships between the two functions.

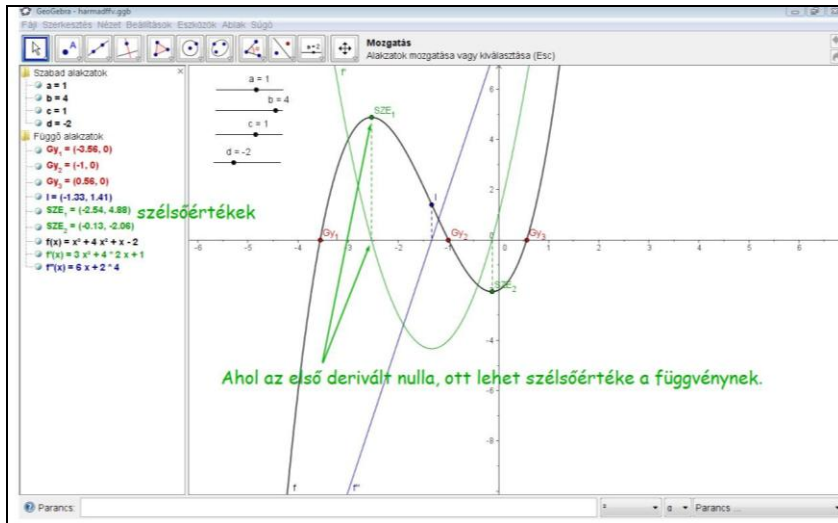


Figure 3: Extreme point of a function and the derivative function

In the questionnaire responses, the majority of participants agreed (64%) or strongly agreed (28%) that GeoGebra is easy to use and potentially useful for their teaching (28%, 72%). Similarly, they found IWB easy to use (51%, 21%) and possibly useful for their work (21%, 52%). But, from the written responses and interviews it could be suggested that participants perceived the potential of GeoGebra and IWB together to be even more powerful than using the two kinds of technologies separately. Finally, the majority of participants (78%) highly valued the workshops and were interested in attending future activities.

Technology, teaching and pedagogy

In both the interviews and written responses participants highlighted that the synergy of utilising GeoGebra and IWB together could amplify the inherent teaching potentials of both tools. The amplification of potentials could be looked at from two directions.

On the one hand, GeoGebra contributes positively to the IWB-equipped environment. Participants suggested that most IWB software contains only basic geometric construction tools such as ruler, compass, and protractor, and thus the wide-

ranging tool selection of GeoGebra can extend the visualisation opportunities of the IWB environment:

I really like the easy user interface and its [GeoGebra's] wide-ranging applicability in mathematics [...] and these can be well used in addition to the IWB software tools.

Teachers also commented that constructions on the IWB are static, but with GeoGebra dynamic figures can show a multitude of solutions for the same problem without redrawing figures:

While answering geometric questions it can be very useful, because we can analyse multiple cases without redrawing figures. Figures and numbers are changing continuously [dynamically] and it is different than calculating something and doing it again [...] it is a special kind of empirical observation.

GeoGebra can also offer a convenient transferability among different kinds of IWB types and software. The software generates a single file, which provides transferable constructions between different IWB environments. In Hungary, schools use more than 17 types of IWB and many schools have a variety of IWB types in use:

I just take the files [GeoGebra] with me and they are ready to use with the other board.

On the other hand, the IWB environment adds interactivity compared to projected images of GeoGebra worksheets. Using an IWB with GeoGebra allows students to see the gestures and constructions of teachers rather than just observing the teacher behind the computer and a pointer moving on the screen. This kind of work connects the movements and images in the classroom:

It allows me not to hide behind the computer, but draw objects just as I would do on the blackboard. [...] Usually what happens is that I use the IWB pen instead of the mouse and exploit the advanced features of GeoGebra. In this way, I can be at the board all the time.

In addition, the classroom dynamics can be changed by the use of IWB because students can be asked to draw on the board and work together rather than just perform actions on computers:

Many students know how to use GeoGebra well. When we work with it on the board [IWB] they become excited to show their constructions [...] there is a lot of movement in the classroom [when working at the IWB].

The IWB pens extend the use of GeoGebra, because freehand drawing is not available on the software yet. Drawing by hand can be followed by more precise objects drawn in GeoGebra:

[...] I use the pen to highlight points and lines and when we have a solution or conjecture I just select a tool [GeoGebra] to draw it properly [...]

The trace of various geometrical objects is an important visualisation tool for GeoGebra, but it is cleared by the software if windows are refreshed. However, participants pointed out that GeoGebra traces can be captured by the IWB software and used later in other situations.

Participants generally suggested that both technologies can contribute to motivate students to learn, but using them jointly can extend this motivation factor even further:

[Using technology in the classroom] can greatly interest students in general and using a mathematical software can be quite visual and useful, but when they can work with it at the front it is even more inspiring.

Besides the different advantages of GeoGebra and IWB use it was evident, through our preparation of workshops and from feedback, that the design of GeoGebra worksheets should be different for IWB (or projection) environments than those designed for personal computer use. The choice of colours, font sizes, line styles and thickness

should be chosen appropriately for adequate visibility. In addition, interactive elements of GeoGebra (sliders, check boxes, and dynamic text) should be placed on the screen where they are reachable by both students and teachers. By developing a special version of GeoGebra for IWBs, such settings can be employed as default and additional IWB features can be integrated into the software.

Suggestions for software improvement

By developing a set of visibility requirements these can become a default setting of GeoGebraIWB. In addition to considering the location of interactive worksheet elements, the toolbar of GeoGebra should be easily reachable for users on IWB. Currently the toolbar and menus are located at the top of the screen, but based on the recommendations of the project the new version of the software will include movable toolbars and windows. Some participants suggested that the keyboard of various IWB software packages offers rather inconvenient text input options. Therefore, the new version of GeoGebra will offer an optional pop-up keyboard for text-requiring fields. Another difficulty emerged in relation to the sensibility of IWB environments. GeoGebra was originally designed for computers and not touch screens so that the sensibility of moving objects will also be improved in GeoGebraIWB. As was mentioned in the previous section, the trace option of GeoGebra is an important exploratory tool for teaching, and it would be useful to have different layers (foils) within GeoGebra so that traces can be recorded within the software rather than captured by the IWB software. Finally, hand-writing recognition was suggested by participants, but it probably needs substantial time to develop:

There are issues which could be addressed with Artificial Intelligence. For example, if I draw a 'circle' with the pen on the board it [GeoGebra] could recognise it and draw a proper circle. But, I know it leads far away.

We are working on documenting the required software improvements and hoping to have them included in GeoGebra in the near future.

Conclusions

Most of the described results are in accordance with the advantages and disadvantages that Higgins, Beauchamp, and Miller (2007) highlighted in their IWB-related literature review. However, this study focuses on the joint use of a dynamic software and IWB. According to Higgins et al. (2007), and most papers in their review, IWB changes the interactivity in the classroom environment among the teacher, the material, and students. GeoGebra was originally designed to offer interactivity by itself in a computer-based environment, but its use together with IWB adds a further layer to the complexity that the interactivity of the software together with the board offers. The design of professional development activities, building on continuous feedback of participants, enables us to better understand aspects of GeoGebra-IWB environments and to recommend alternation of the software to better suit these new challenges.

In addition to the direct changes in the software, we were able to improve workshops to be offered in the upcoming year. We are continuing this project with further data collection and have extended it to videotaping participants as they apply their knowledge from the workshops to their own classrooms. During the past few months, we have presented the results of this study at some international conferences and received interest from a number of colleagues from different countries who intend to trial

workshops in their own countries and contribute to the further improvement of professional and software development.

Zsolt Lavicza is currently an Associate Lecturer in Mathematics Education at the University of Cambridge. His research focuses on the integration of digital technologies into mathematics teaching and learning. In addition, he is coordinating the development of local GeoGebra Institutes and offering research support within the International GeoGebra Institute.

Zsuzsanna Papp-Varga is a lecturer at the Department of Computer Science at Eötvös Loránd University. Originally her research focused on symbolic computations, but during the past four years she became involved in various GeoGebra-related projects. She is currently the coordinator of the Hungarian translator and professional development teams in Hungary.

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