

Establishing a Professional Development Network around Dynamic Mathematics Software In England

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In this paper, we will outline some results of an NCETM (National Centre for Excellence in the Teaching of Mathematics) funded project that aimed to establish a professional development network with an open-source mathematical software – GeoGebra – in England. During the past few years a large international user and developer community has formed around various GeoGebra-related activities. Most teachers who are currently using GeoGebra have not received professional training in the implementation of the software in their teaching practices, but have begun using it due to their enthusiasm or encouragement by their colleagues. However, research suggests that, for the majority of teachers, solely providing technology is insufficient for the successful integration of technology into their teaching. 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. Thus, in our project, involving nine experienced English teachers, we outlined some priorities for professional development and developing supporting materials for English teachers.

1 INTRODUCTION

The principal aim of this project was to conduct research on GeoGebra-related professional development materials and approaches. The study was conducted through tight collaboration of educational researchers and mathematics teachers in England utilising frameworks of communities of inquiry (Jaworski, 2006) and collaborative design (Cobb, Confrey, diSessa, Lehrer and Schauble, 2003). By joint collaboration and design we hoped to establish a core group of GeoGebra experts in England who can offer professional development and support for teachers. We also wanted to explore the ways in which GeoGebra can be used to enhance the teaching and learning of mathematics within the English curriculum.

In addition, there is a broader impact of the findings from this project as it not only informs the national mathematics education community about the affordances of new mathematics learning technologies, curriculum design and teacher professional development, but also contributes to a broader international community. Through the international developer and research network of the

International GeoGebra Institute (Hohenwarter and Lavicza, 2007) findings of this project assist in setting up and designing broader projects. Hence, this project contributes to developing self-sustaining support and professional development networks not only in England but also in other parts of the world.

2 RATIONALE AND AIMS

There is increasing consensus among mathematics educators that technology is becoming an integral part of mathematics teaching and learning, affording new forms of dynamic representations and communication (Heid and Blume, 2008; Kaput, Hegedus and Lesh, 2007). Indeed, 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 and Kaput, 2008). Furthermore, through "thought-revealing activities" (Kelly, Lesh and Baek, 2008), these rich and interconnected representations have the potential to enhance students' mathematical experiences and foster deep understanding of mathematical concepts (e.g. Hiebert, Carpenter, Fennema, Fuson, Wearne, Murray, Oliver and Human, 1997). However, these studies highlight the importance of appropriate professional development to support teachers in designing technology-supported lessons.

There is a general agreement among mathematics educators on the powerful pedagogical and cognitive roles of the new dynamic multiple representations. However, for the majority of teachers, solely providing technology is insufficient for the successful integration of these new dynamic tools into their teaching (Cuban, Kilpatrick and Peck, 2001). 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. Furthermore, mathematics teachers play a vital role in the iterative cycle of curricular planning, development, implementation, and assessment (Clements, 2007). Heid and Blume (2008) recommended a stronger focus on research that "helps teachers, curriculum developers, and researchers to understand how students move between, connect, and reason from multiple representations" (p. 98). The paucity of such research is disproportionate to the increasing popularity of

new mathematical learning environments and the growing interest among classroom mathematics teachers in experimenting with new approaches to mathematics education. 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 (Ruthven and Hennessy, 2002).

Nevertheless, the introduction of technology into mathematics teaching has proven to be a much more complex process than initially expected (Cuban et al., 2001). Teaching in general, and teaching with technology, in particular, has been found to be a “wicked problem” (Koehler and Mishra, 2008, 10), introducing additional complexity and new layers of structures in the real classroom. To ease the complexity of technology integration in mathematics education, recent research endeavours have resorted to community-based inquiry and curricular design (Jaworski, 2006).

These approaches can be used as tools to foster mathematics teachers’ investigation of mathematical content, mathematics teaching, and higher-level reflection on teaching and technology. By engaging classroom teachers as researchers and curriculum designers, research teams are better oriented to address the complexity of mathematics teaching. Collaboratively, teachers and researchers critically explore the multifaceted relationships among the subject matter, teaching, and the use of technologies in a manner that takes into account both the teaching practice and context (Koehler and Mishra, 2008).

In this project, we chose to work with a specific software package GeoGebra due to various reasons. At the recent 11th International Congress on Mathematics Education (ICME-11), the permanence and potential, yet ongoing challenges, of technology use in mathematics education were highlighted by several respected speakers (e.g. Artigue, Kilpatrick, Hoyles). The open-source dynamic mathematics environment GeoGebra represents one such software program that was designed to combine arithmetic, algebra, geometry, and calculus in a single, integrated system (Hohenwarter and Preiner, 2007).

GeoGebra is a freely available dynamic mathematics environment and offers dynamically linked multiple representations for mathematical objects (Hohenwarter and Jones, 2007) through its graphical, algebraic, and spreadsheet views for teaching and learning mathematics at all levels. It also allows the creation of interactive on-line resources which are freely shared by mathematics teachers on a collaborative online platform.

GeoGebra is currently available in 50 languages and used by hundreds of thousands of teachers and students in over 190 countries. Given the open-source nature, web-accessibility, and the growing international user community, GeoGebra is not only intellectually promising software but also economically sustainable in empowering classroom

teachers to support all students in learning significant mathematics (Hohenwarter, Jarvis and Lavicza, 2009).

In sum, the principal aims of the project were to (1) nurture a community in England around GeoGebra, (2) find how GeoGebra can be integrated into the curriculum, (3) develop professional development workshops together with participating teachers, and (4) professionalise participating teachers by giving workshops for other teachers, involve them in research, present at conferences, and write papers together.

As was discussed above, in order to achieve these goals, the theoretical framework of the project was informed by Barbara Jaworski’s (2006) theoretical conception of communities of inquiry and we also drew on the literature related to design experiments.

3 PARTICIPANTS AND ACTIVITIES

The project team consisted of four research team members and nine participant teachers. Originally we proposed to work with four teachers in this project, but due to overwhelming enthusiasm of potential participants we decided to expand the team to nine teachers from a variety of locations in England who were teaching at different grade levels in their schools.

We held three project meetings and met at local conferences to discuss our experiences and to develop materials and pedagogical approaches for the workshops that were led by teachers involved in the project. After outlining and collaboratively considering the aims of the project, the project participants organised 12 workshops that were held for different audiences and at various locations. Further details of participants, workshop locations, and material development can be found in Lavicza, Hohenwarter and Lu (2009).

Workshop participants ranged from primary to A-level teachers, involved pre-service and in-service teachers and heads of mathematics departments. Several workshops were organised within NCETM regional seminars, and workshops were held at schools, universities, and training centres. The individual workshops usually lasted for 2-3 hours, but there were some full day workshops as well. We disseminated the project at local conferences and NCETM meetings, which resulted in further interested teachers and additional workshops.

3.1 Data collection

Project meetings were videotaped, and presentation slides together with GeoGebra files were collected. We aimed to also videotape all workshops which unfortunately was not possible logistically, however we were able to collect video records from five workshops. In addition, we collected participants’ work and asked them to fill in a short questionnaire about their experiences in these workshops. Presenters also filled in a short questionnaire about the workshop. In addition, we interviewed several participants and collected presentation materials.

3.2 Data analysis

Videotapes were summarised and important parts of them were selected by the research assistants of the project. These parts were then reviewed and transcribed together with the researchers. The data from questionnaires was entered into a spreadsheet file and analysed with SPSS and Excel software. Written responses and interviews were analysed with the help of HyperResearch software. In the data analysis we followed a Grounded Theory approach (Strauss and Corbin, 1998).

4 RESULTS

Due to the page limitation of this journal issue, we report on only the pedagogical developments of the project, but other results are available and are reported in other papers (e.g. Lavicza et al., 2009; Jones, Lavicza, Hohenwarter, Lu, Dawes, Parish and Borchers, 2009) and further publications are planned.

4.1 Community of practice for professional development

Engaging participants in collaborative activities was very successful. Throughout the meetings participants proposed various ways to set up professional development structures. It was outlined that in order to develop successful professional development we would need to consider how to organise GeoGebra materials and develop workshops accordingly. It became clear that we needed to aim for a range of teaching styles and develop workshops according to teaching levels fitting different pedagogical approaches. Within these stages we would need to develop materials for teaching different topics.

In addition, beyond the presentations we needed to develop handouts and tutoring materials. In the meeting we reviewed the already available teaching materials developed in other related projects in the United States (Lavicza, Hohenwarter and Hohenwarter, 2008) and agreed that they would need to be altered considerably for the English audience. The U.S. materials were very detailed and participants suggested that English teachers would welcome

more openness and creativity so reducing the level of detail could improve the acceptance by teachers. Furthermore, the developed materials should not be prescribed, but rather customisable.

To achieve these aims we decided to develop a pool of materials, in line with the philosophy of the project, from which participants can draw for their own workshop. Therefore, we established an online project wiki site where participants could share materials and comment on their use.

We also discussed the necessity of producing materials for people with different levels of GeoGebra knowledge, but we assumed that most participants would have had little experience with GeoGebra and thus we concentrated on introductory workshops. In the next section, we discuss one of the approaches our nine teacher participants outlined to organise professional development and to help teachers to introduce GeoGebra into their classrooms.

4.2 Step-wise immersion approach

The developed workshops included an introduction to GeoGebra including hands-on activities in which some basic problems from geometry and algebra were given. Several presenters used a slightly modified version of the GeoGebra QuickStart document from the GeoGebra website. However, it was also important to discuss how GeoGebra fits into the national curriculum of England. In workshops participants received a summary table from the national curriculum and jointly discussed opportunities for GeoGebra use in their teaching.

More importantly, participants discussed the importance of pedagogical approaches in GeoGebra environments. Below, we give an example of the pedagogical framework that was presented at our workshops. Workshop participants received an A3 sheet including Figure 1 which they used in group discussions about different ways how GeoGebra could be used in their teaching.

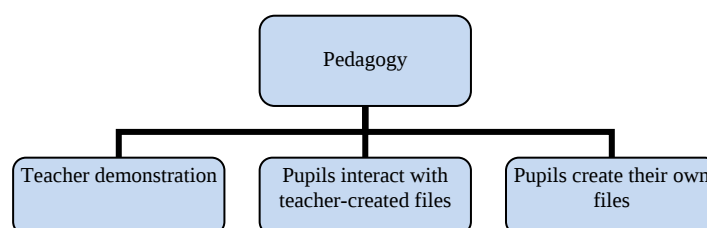


Figure 1 Pedagogical approaches with GeoGebra

Examples of these three categories were presented and discussed at the workshops. Figure 2a, b shows an example of a teacher demonstration to engage students in discussing a dynamic construction. Firstly, the teacher can ask questions about the objects on the screen and what students expect would happen if some parts of the

configuration are moved or changed. Then either the teacher or some students can change the construction to check their predictions.

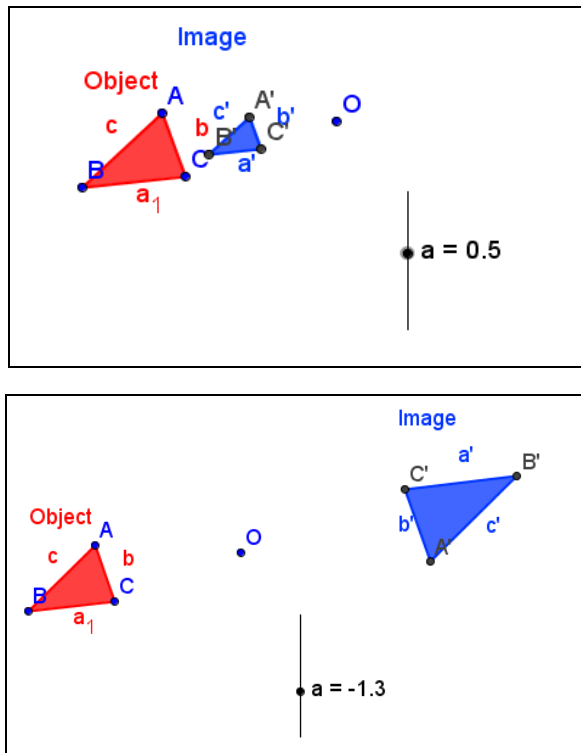


Figure 2a, b Example of teachers' demonstrations:
"Enlarging by a Factor"

According to discussions within our project, such demonstrations allow teachers who have little experience using technology in classroom teaching to experiment with technologies with small risk. In addition, this kind of use requires less change in the classroom environment and needs fewer resources than organising classes in computer labs.

When teachers become more comfortable with computers they can provide pre-developed worksheets for students with tasks and students can experiment with dynamic objects. In Figure 3, students are presented with a symmetric face where they can play with its shape to make conjectures about the properties of symmetries. In addition, when they have become familiar with the construction they can create new objects on the face (such as hair, eyebrows and spots) that bear the same dynamic properties as the already existing face.

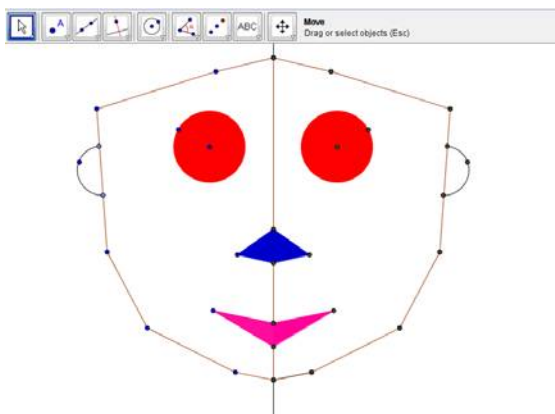


Figure 3a Example of students interacting with a teacher created file: "Face"

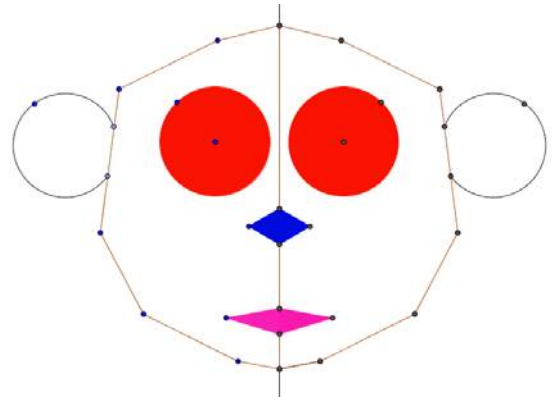


Figure 3b Example of students interacting with a teacher created file: "Face"

Finally, the teachers can ask students to create their own files to help them develop conjectures, theories, and proofs (Figure 4a, b, c).

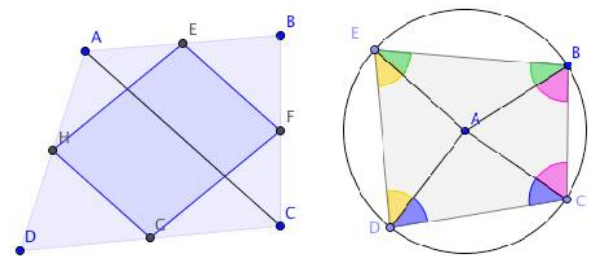


Figure 4a, b Example of students creating their own files

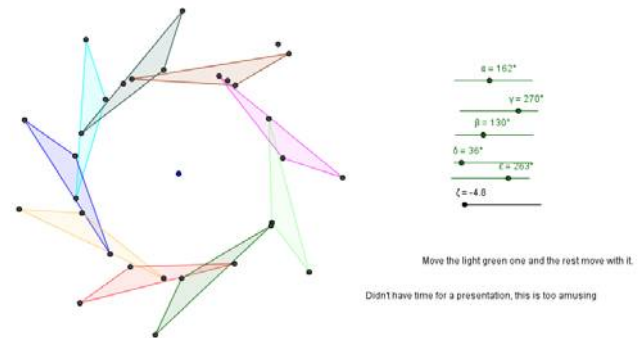


Figure 4c: Example of students creating their own files

The sequence of these activities was discussed by the participants in the project. We agreed that this could be a good way to present GeoGebra for teachers with limited technology integration experience. This development of activities is very similar to a study carried out by Laborde (2001). She followed two teachers for two years and tried to understand how novice teachers integrate technology into their teaching. Laborde (2001) found that teachers gradually grant control of technology and the learning environment to students. In other words, they mostly use demonstration at first and then slowly allow the individual use of computers by students in their classroom.

However, technology integration is a more complex process than just considering teachers' actual activities. Ruthven (2007) identified five aspects:

- 1) working environment;
- 2) resource system;
- 3) activity format;
- 4) curriculum script;
- 5) time economy;

that influence teachers decisions in using technology for teaching. Ruthven (2007) explained the interaction of these aspects in teaching decisions and activities:

“Each of these modifications of an established activity format calls for the establishment of new classroom norms for participation, and of classroom routines to support smooth functioning.” (p. 10).

In future studies it would be advisable to consider not only the development of teachers’ activities, but also the factors that influence teachers’ decisions in classrooms.

In sum, the teachers engaged in discussion and developed activities and ideas that could be useful for further improvement of professional development activities. These ideas and activities also corresponded with previous research. Furthermore, through the project meetings and e-mail/wiki exchanges, participants formed a community that has clearly contributed to the success of the project. It also became apparent that the professional development activities highly depended on the accessibility, sharing, and exchange of resources and ideas among participants. Thus, developing on-line, easily accessible and searchable local resources is crucial for the future.

5 SUMMARY

We believe that we reached most objectives of the project described above and developed/collected materials that will be applicable for developing further projects and establish professional development in England. With a group of nine enthusiastic participants we initiated a core group which can begin developing support and professional development to other teachers in England.

We also investigated ways in which GeoGebra can be integrated into the English curriculum and began developing and collecting materials that can be used in mathematics teaching and learning. In addition, we laid down the principles for establishing a local searchable GeoGebra site and on-line support structure. Certainly, this project only offers initial steps for developing more extensive professional development activities. We aim to extend this work and to utilize the knowledge and materials to further develop and trial professional development workshops.

Finally, but not least, participants became interested in research and sharing their experience with other teachers in conferences and through various publications. Thus, we believe that with this project we contributed to the professional development of teachers in England and supported the aims of NCETM.

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BIOGRAPHICAL NOTES

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Allison Lu is a PhD student at the Faculty of Education, University of Cambridge. She has been a research assistant of this project and writes her dissertation on the integration of dynamic mathematics software into secondary education.

Mark Dawes is teacher at Comberton Village College in England as well as working as a part time teacher trainer at the University of Cambridge. He was one of the nine teachers involved in our NCETM project and has given several GeoGebra workshops and contributed to the project report and this paper.