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BSRLM Geometry working group: Establishing a professional development network to support teachers using dynamic mathematics software *GeoGebra*

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The embedding of technology into mathematics teaching is known to be a complex process. *GeoGebra*, an open-source dynamic mathematics software that incorporates geometry and algebra into a single package, is proving popular with teachers - yet solely having access to such technology can be insufficient for the successful integration of technology into teaching. This paper reports on aspects of an NCETM-funded project that involved nine experienced teachers collaborating in developing ways of providing professional development and support for other teachers across England in the use of *GeoGebra* in teaching mathematics. The participating teachers tried various approaches to better integrate the use of *GeoGebra* into the mathematics curriculum (especially in geometry) and they designed and led professional development workshops for other teachers. As a result, the project initiated a core group which has started to be a source of support and professional development for other teachers of mathematics in the use of *GeoGebra*.

Keywords: mathematics; geometry; ICT; technology; teaching; professional development; CPD; *GeoGebra*; NCETM

Introduction

Technology is becoming integral to mathematics teaching and learning, affording new forms of dynamic representation and communication (for an overview, see Heid and Blume, 2008). Yet it is also clear that the need for appropriate professional development to support teachers in designing technology-supported lessons remains paramount. Solely providing technology is insufficient for the successful integration of new dynamic tools into teaching. As Cuban, Kilpatrick and Peck (2001) report, providing access to equipment and software does not necessarily lead to widespread teacher and student use of the technology.

Yet there is evidence that appropriate professional development opportunities and collegial support can boost teachers' willingness to integrate technology into their teaching and can support their capacity to develop successful technology-assisted teaching practices (Heid and Blume, 2008). Part of this might entail aiding teachers in understanding the affordances, constraints, and general pedagogical nature of such new representational resources in relation to the specific topics in school mathematics (Hohenwarter and Jones, 2007; Ruthven and Hennessy, 2002).

This paper reports on selected components of a project funded by the *National Centre for Excellence in the Teaching of Mathematics* (NCETM) for England. The project involved nine experienced teachers collaborating in developing ways of providing professional development and support for other teachers across England in

the use of the open-source dynamic mathematics software *GeoGebra* in teaching mathematics. In what follows, a brief overview is given of the software *GeoGebra*. The bulk of the paper documents selected elements from the forms of professional development and support for other teachers that were developed as part of the project

An overview of GeoGebra

GeoGebra (Hohenwarter, 2002; Hohenwarter and Preiner, 2007) is a free-to-use open-source dynamic mathematics software that incorporates geometry and algebra into a single package by providing an integrated connection between the symbolic manipulation and visualisation capabilities of CAS (Computer Algebra Systems) and the dynamic changeability of DGS (Dynamic Geometry Systems). It does this by providing not only the functionality of DGS (in which the user can work with points, vectors, segments, lines, and conic sections) but also of CAS (in that equations and coordinates can be entered directly and functions can be defined algebraically and then changed dynamically). These two capabilities are characteristic of *GeoGebra* which, as shown in Figure 1, provides two windows in which each object in the algebra window corresponds to an object in the geometry window, and vice versa (for more on this, see Hohenwarter and Jones, 2007).

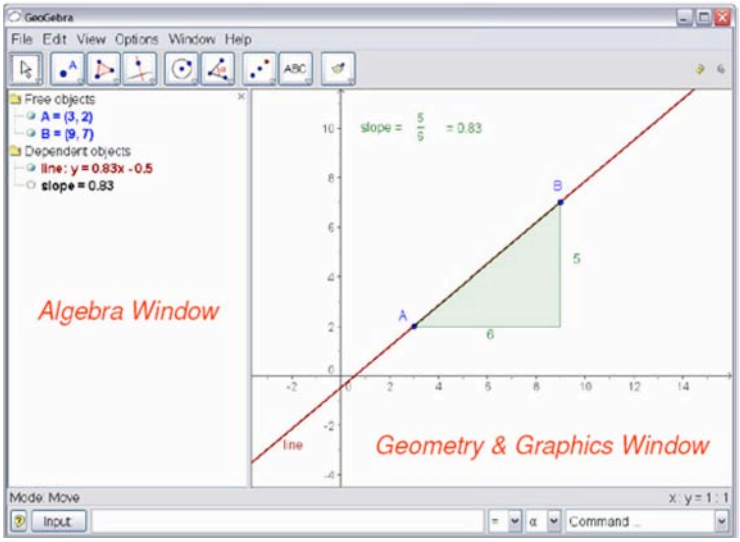

Figure 1: *GeoGebra* screen showing both the algebra and geometry windows

The upcoming update to *GeoGebra* is, at the time of writing, nearing release (see Kreis, 2009). New features include the addition of spreadsheet capabilities (linked to existing capabilities in algebra and geometry), plus, amongst other things, statistics functions and support for the use of complex numbers. In addition, custom animation of objects is becoming fully integrated into *Geogebra* with the provision of animating sliders with which the user can specify the increment, the speed, and what happens when a boundary is reached (at which point the object can bounce, or repeat). More information on *GeoGebra*, including updates and sources of teaching ideas, can be found at www.geogebra.org

The project to establish a professional development network in England

The project team for this NCETM-funded project was made up of researchers and teachers. The principal aims were to nurture in England a professional development network around the use of *GeoGebra,* to find ways in which the use of *GeoGebra* can

be better integrated into the mathematics curriculum, to develop CDP workshops, and to enhance the professional opportunities for participating teachers by supporting them in giving workshops for other teachers and involving them in original research and in conferences and other forms of research dissemination.

The project was informed by several theoretical ideas, primarily the notion of communities of inquiry (Jaworski, 2006). The methodological framework is that of the design experiment (Gravemeijer, 1994). Data are from interviews with participants and the analysis of video recordings of the CPD workshops.

The facets of the project reported below are those concerned, first, with efforts made by the participating teachers to better integrate the use of *GeoGebra* into the mathematics curriculum and, second, concerning how the project team designed professional development workshops. More details are in Hohenwarter and Lavicza (2007) and the full project report presented in Lavicza, Hohenwarter and Lu (2009).

Integrating the use of *GeoGebra* into the mathematics curriculum

Given that much current use of dynamic geometry software is in upper secondary school mathematics, this component of the project examined the geometry requirements of mathematics curriculum in England to find ways in which *GeoGebra* might be used with younger pupils in the primary and lower secondary school years. The initial stages of the project showed that *GeoGebra* offered the opportunity for teachers of the youngest pupils to work with, and extend their knowledge of, basic 2D shapes by using pre-prepared files (or their own) with the interactive whiteboard or with an adult working with a small group on a computer. Later on, pupils were shown how to develop ideas themselves from base files or how to create their own examples. Work on the project suggests that it is possible to use *GeoGebra* in teaching many of the concepts found in the geometry area of the school curriculum, offering benefits to pupils such as developing a good vocabulary, being able to experiment with ideas more rapidly than drawing by hand, produce accurate drawings, and gaining instant feedback. An example developed during the project of a classroom task involving reflection in a line is shown in Figure 2.

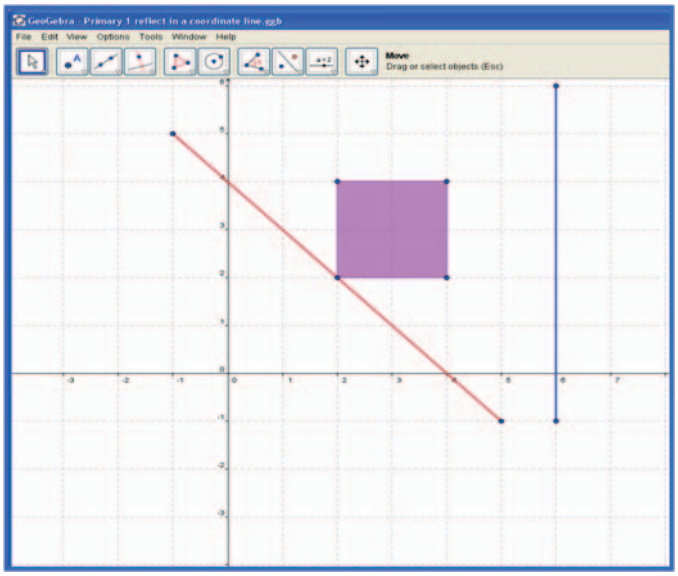

Figure 2: *GeoGebra* screen showing a reflection task

More examples of tasks that were developed during the project can be found through the online *GeoGebra Wiki* at: www.geogebra.org/en/wiki

Developing and providing professional development for teachers

In this component of the project, participating teachers not only contributed to the development of professional development materials, they also led workshops for other teachers. The workshops developed during the project included providing an introduction to *GeoGebra*, with hands-on activities during which some basic problems from geometry and algebra were tackled by the participants.

A particularly promising approach to stimulating professional conversations about teaching approaches is the pedagogical framework, illustrated in Figure 3, which was developed during the project. This pedagogical framework was presented at the CPD workshops and provided both a way of structuring discussion and a prompt for further discussion and further work.

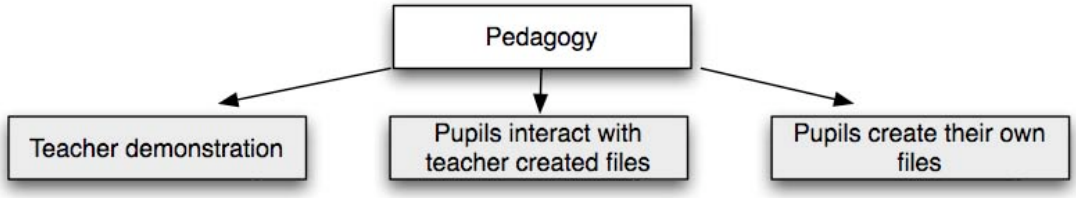

Figure 3: Pedagogical framework of approaches with *GeoGebra*

Examples of the use of each of the three approaches summarised in Figure 3 were presented at the range of CPD workshops conducted as part of the project. In the first of these approaches, that of teacher-demonstration, the teacher engages students in discussing a dynamic construction using *GeoGebra*. With this approach, the teacher can ask questions about the objects on the screen and get students to explain what they might expect would happen if some parts of the configuration were moved or changed. Then either the teacher or some students can change the construction to check such predictions.

Such demonstrations, it was found during this project, allow teachers who have little experience with using technology in the classroom to experiment with the technology with relatively small risk. In addition, this kind of use of technology requires less change in the classroom setting and needs fewer resources than organising classes of students into a computer room or when using a class set of laptops in the regular classroom.

When teachers become more comfortable with computers the second approach captured in Figure 3 entails teachers providing previously created *GeoGebra* files for their students. With such teacher-created files, students can experiment with dynamic objects. Such an approach provides clear boundaries for students and student time is not spent setting up the task. Instead, students can spend time exploring the mathematics that is central to the task. There is quite some teacher control over the material, but the approach also brings in opportunities for creative thinking and problem solving by students.

It was recognised in the CPD workshops that this approach of students using teacher-created files to explore problems may well mean teachers transforming the way they are teaching. It entails teachers experimenting with the content of their lessons and adopting a more investigative approach. It might also mean highlight different aspects of mathematics and might entail working with different starting point, both of which should stimulate discussion and the sharing of ideas in the classroom.

Yet, while there is the potential for student engagement with such teacher-created files, it may be that some such files may engender little more the procedural thinking in students. There is also the danger of a lack of student engagement, with no more than random play (perhaps unproductively) with the file. What is more, students may not relate to the problem as there is a lack of ownership which could be restrictive.

The third approach captured in Figure 3 entails students creating their own files, perhaps for other students to tackle. This approach provides ownership of the work and engages a different sense of problem solving and thinking by creating that ownership. There is also the development of independence – in learning how to use *GeoGebra*, and with more scope for student creativity and discovery. Students are being imaginative, creating their own 'What ifs?', and, as such, may be more likely to go and use *GeoGebra* for themselves, perhaps at home. No doubt there are risks too with such an approach; something that discussed by participants during the CPD workshops. For example, students creating their own files may well be time consuming, and such creations may not have the desired impact.

Outcomes and discussion

According to a recent research report on the state of overall continuing professional development of teachers in England (Pedder, Storey and Opfer, 2009: 13), "teachers place most value on CPD that involves experimenting with classroom practices, working collaboratively, and adapting approaches in the light of pupil/peer feedback and self-evaluation". In a similar vein, the recent NCETM project on effective CPD in Mathematics Education (NCETM, 2009: 3) reports that "teachers valued practical advice that was directly applicable to the classroom, including resources and banks of resources that they could use with minimal adaptation. In many cases they valued having attention drawn to the use of practical equipment and ICT resources which support mathematical thinking and reasoning". This project sought to all do these things, and more.

The project examined various ways of supporting teachers in building their capacity to develop successful technology-assisted teaching practices. One component of the project entailed working on ways in which *GeoGebra* could be integrated into the mathematics curriculum in England and one outcome has been the developing and collecting of classroom materials that can be used in mathematics teaching.

Another component of the project involved the participating teachers not only contributing to the development of CPD materials, but also leading workshops for other teachers. With a group of nine enthusiastic participating teachers, the project has initiated a core group that is ready to continue developing support and CPD for other mathematics teachers in England.

Concluding comment

It is fitting to conclude with noting that the group of teachers who collaborated in the project have become interested in research and in sharing their experience with other teachers at conferences and through various publications. We hope that reports on this project further contribute to nurturing a community of teachers and researchers in England who are interested in developing and using open-source technology in schools and in teacher education.

Acknowledgements

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BSRLM geometry working group

The BSRLM geometry working group focuses on the teaching and learning of geometrical ideas in its widest sense. Suggestions of topics for discussion are always welcome. The group is open to all. See: www.bsrlm.org.uk/workinggroups.html