Using dynamic geometry software GeoGebra in developing countries: A case study of impressions of mathematics teachers in Nepal

Bhesh Raj Mainali¹ and Mary Beth Key²

This article describes a professional development initiative for fifteen mathematics teachers in the use of dynamic geometry software GeoGebra. A four-day introductory workshop was given in Nepal to provide an overview of GeoGebra and its possible integration in the teaching/learning of secondary school mathematics there. Teachers’ impressions and beliefs concerning both the training and the software were researched in the context of applicability in Nepalese schools. The potential for using GeoGebra to teach and learn mathematics in Nepal is very large, as evidenced by the participants’ impressions and enthusiasm about, and willingness to use, dynamic geometry software, despite many constraints and difficulties associated with accessing advanced technology.

Key words: Dynamic geometry software, professional development, pedagogical content knowledge, teacher impressions and beliefs.

Introduction

Traditional methods of teaching and learning are still dominant in Nepal, so professional development in more modern pedagogical practice is an area deserving close attention. As it is, teachers ‘distribute’ knowledge and skills to their students who in turn memorize facts, definitions, and algorithms, but who have little or no practice in thinking for themselves. The situation is similar in the preparation for examinations for which students are encouraged to use the drill-and-practice method.

Significant is the importance of the national examination in countries like Nepal. A secondary student’s academic future depends on her/his success on the national examination given at the end of secondary school. Students whose scores fall below a certain level might not be able to study the natural sciences, and it is difficult to get admission to a good college. The result is that teachers mostly feel locked into preparing students for the national examination. It can be said, therefore, that teaching in such countries is largely examination driven, far more than in other places where in addition to a national examination, university entrance also depends on a range of other factors, including school performance and teacher references. For this reason alone, the traditional instruction style in countries like Nepal is advocated not only by teachers but also by parents. Thus, Nepalese education is strongly influenced by content and by examination-driven practices, with little or no attention paid to encourage students to use their knowledge and skills to solve practical problems, or to try to access their own, already acquired knowledge and construct new ideas. Examination pressure may also be a mitigating factor against use of pedagogies of other than the traditional, or

¹ B. R. Mainali, Doctoral student, University of Central Florida, College of Education, Department of Teaching, Learning and Leadership, Orlando, Florida, USA. His professional interests include the integration of technology in the teaching/learning process of mathematics for secondary school. email:  mmarad@gmail.com
² M. B. Key, Senior Lecturer, Korteweg-de Vries Institute for Mathematics, Faculty of Science, University of Amsterdam, The Netherlands. Her professional interests focus on innovations in the professional development of mathematics and science teachers. This concerns support for a move towards use of more student-centered approaches. email:  m.e.key@uva.nl
anything else that is deemed to require “more time” than the lecture mode of instruction. In such an environment professional development takes on an added dimension of difficulty: expectations for teacher change may not be met because teachers’ present practice produces students who are successful on the national exam. However, a solution may lie in enabling teachers to gain sufficient confidence and experience in working with Dynamic Geometry Software so that they try with their own students.

Currently, Information and Communication Technology (ICT) has a minimal to nonexistent role at secondary school level in Nepal. Lack of both resources and investment are among the reasons; however, a larger problem may be the low priority placed on building an education system which will enable Nepalese young people to function better in the modern world. For example, there is no clear vision regarding the use of ICT in the classroom by either teachers or students. Although the government of Nepal has initiated a school reform project in which ICT-assisted and “child-friendly” teaching/learning are encouraged in all schools (Ministry of Education Nepal, 2007), no noticeable implementation is yet evident. Teachers simply do not know how to go about incorporating either of these. Some private secondary schools and some public schools do have computers, and in such settings there are attempts to motivate students to use this advanced technology; however, these efforts are limited in general as they only address students’ computer literacy in very basic ways, for example by training them to access the internet, do word processing, and work with spreadsheets. Apart from these few instances, there appears to be little evidence in Nepal of ICT use in secondary schools for broader educational purposes, nor do teachers appear to have encountered ICT use in subjects such as mathematics. Indeed, there appears to be little or no encouragement of students to explore concepts that they are expected to know or to enable them to do so in a digital environment.

In an effort to begin some small change in the present situation, in 2008 the first author began a professional development initiative targeting Nepalese mathematics teachers to introduce them to the Dynamic Geometry Software (DGS) package, GeoGebra. Over a three year period some small trainings were provided on an ad hoc basis to teachers hearing about them by word-of-mouth. This initiative culminated in a training package supported by the National Teachers Association. Two overarching concerns were as follows. Even if teachers could learn to use DGS in a professional development situation, would they use it in their classes? Would the training results be sustainable so that teachers would continue using it in the future, and moreover use it in their schools with their own students?

Purpose of the study

GeoGebra is an interactive mathematics software package incorporating geometry, algebra, and calculus, each of which can be used separately. In the context of a developing country like Nepal, open source (public domain) software like GeoGebra is most important since it can be downloaded without cost by anyone with internet access. Our general aims were first to alert mathematics teachers to the existence of open source software; then to train them to access and use a particular DGS package (GeoGebra). Further, we wanted to enable them to try DGS in their own classrooms. The focus was on enabling teachers to gain both skill and some confidence to work in a digital environment.

As a corollary to these aims, it seemed important that teachers should be encouraged to become competent users of GeoGebra and thereby achieve some confidence, if they were to contemplate testing a new (for them) type of pedagogy in the often poorly equipped and crowded classrooms of typical Nepalese schools. Finally, a main issue for teachers in a developing country like Nepal relates to possible technical difficulties in using software without technical support in schools.
Dynamic Geometry Software for mathematics

Computer technology is currently easily accessible and becoming a popular teaching tool to the extent that technological literacy is now perceived as a basic skill of teaching (Lawless & Pellegrino, 2007). The importance of using technology in mathematics education has been emphasized by the National Council of Teachers of Mathematics (NCTM) because technology can have a crucial role in teaching and learning mathematics: it both influences the mathematics that is taught and enhances students’ learning (NCTM, 2000, p. 11).

Dynamic Geometry Software offers new tools that go beyond traditional methods, so DGS widens the range of accessible geometrical constructions and solutions (Straesser, 2001). It can be used for visualization of objects and enhance the discovery learning process by enabling students to explore many more examples on the computer screen than is feasible with pencil and paper. This can mean that with DGS students can begin to explore concepts for themselves. Other salient reasons that a mathematics teacher might want to use technology like DGS are:

- **Gives teachers flexibility:** The role played by technology is not fixed and can be changed over time when teachers become more experienced (Laborde, 2001). This means teachers will have increased flexibility in what they want to do and how they do it. For example, digital environments allow teachers to adapt their instruction and teaching methods more effectively to their students’ needs (NCTM, 2000, p. 24).
- **Teachers and pupils become co-learners:** Technology can transform the teaching of mathematical concepts by engaging students in interactive demonstrations, constructions and explorations. Teachers sometimes are co-learners in such ventures as they institute explorations of a mathematics concept (like triangle) and thereby engage in discussions with their students about these explorations.
- **Enables student-centered learning:** DGS programs promote student-directed inquiry and collaborative work with appropriately designed activities through which teachers can offer students opportunity to formulate theories and draw their own conclusions (Hannafin, Burruss, & Little, 2001).
- **Develops thinking skills in students:** Intuition of learners can be brought to a higher level by exposing them to a wide range of mathematical concepts which they can explore for themselves and at times, even discover some mathematics beyond geometry (Hohenwarter, & Fuchs, 2004). Such activity also gives students more control over their own learning.

GeoGebra and Geometric Sketchpad (GSP) are two examples of mathematical software where geometric figures can be manipulated and algebraic operations can be conducted not only by teachers, but at times by students working independently of the teacher. An important advantage of open source software like GeoGebra is that there is no extra financial outlay for schools (or individual teachers and students) to acquire it. So students can download and use it at home and explore their ideas in the absence of their teachers. GeoGebra may be particularly attractive for teachers because it provides a platform for activities that require a high level of thinking. In working with such activities students remain engaged with the interactive features that GeoGebra and other DGS software bring, such as learning from feedback, seeing patterns, making connections, and working with dynamic images (Edwards & Jones, 2006).
Mathematics Pedagogical Content Knowledge includes Technology

Whereas teachers’ content knowledge appears largely established by their own schooling and undergraduate training, their pedagogical knowledge largely stems from their experience as a student (Pajares, 1992), as well as from their previous teaching experience. In speaking of training prospective teachers, Philipps (2008) suggested that: “separating the learning of mathematics from the consideration of issues of mathematics teaching and learning is counterproductive to their development of mathematical content knowledge and to the development of their beliefs about mathematics teaching and learning” (pp. 7-8). It is also to be noted that pedagogical knowledge of reflective teachers may also be influenced by critical reconsideration of their own teaching practice and being alert to students’ learning needs.

The process by which teachers deliver content to learners is connected to both pedagogical knowledge and content knowledge, or Pedagogical Content Knowledge (PCK) as originally proposed by Shulman (1987). The PCK construct refers to “teachers’ interpretations and transformations of subject-matter knowledge in the context of facilitating student learning” (Van Driel, Verloop & De Vos, 1998). “All research in this domain agrees on claiming that PCK is a knowledge that develops with years of teaching experience” (Saeli, Perrenet, Jochems & Zwaneveld, 2011, p. 75). Further, “Hashweh (2005) underlines how the teacher's approach or orientation to his or her discipline (personal beliefs) influences the teaching of a certain topic, and might influence her/his PCK. This means that each teacher’s PCK is in a way personal” (Saeli, et al., 2011, pp. 75-76).³

Jones and Mather (1995) have suggested that technological knowledge and an understanding of technological practice must be combined with appropriate conceptualizations of technology and technology-based education. However, within a subject like mathematics, this must be done by taking into account the nature of the subject mathematics, so that it is mathematics that is learned with increased understanding, with technological skills and knowledge serving as supporting tools (in a Vygotskian sense) which enhance learning though the social environment.⁴ Summarizing, technological knowledge should be incorporated in line with both mathematics content knowledge and mathematics pedagogical knowledge, but it is the mathematics which must be paramount.

To impart knowledge in effective ways and function well in modern schools, teachers need to have an extensive knowledge of content, as well as pedagogy and, for digital environments, some technical knowledge. How teachers use computer software varies with the individual and the subject being taught, but the end result should be that teachers have the knowledge and skill to use the software actively and appropriately with their students. By “actively” we mean regular incorporation of software and suitable peripherals in their classes, and by “appropriately” we are concerned with teachers’ ability to designate and/or develop activities which engage students on a regular basis in exploring for themselves, mathematics concepts within a digital environment. The capacity to use technology in one’s teaching of mathematics, therefore, becomes part of such a teacher’s PCK.⁵

⁴ For a clear discussion of Vygotsky’s use of the word tools, see Cole and Wertsch (1996).
⁵ We recognize the interesting Technological Pedagogical Content Knowledge (TPCK) construct (Mishra & Koehler, 2006), but within a science subject like mathematics, we prefer to retain the PCK construct.
Teacher beliefs and goals and possible effects on teaching

Beliefs and goals, are important cognitive factors that may help to shape the perception of teachers concerning their instructional practice and the role of technology used; along with knowledge, beliefs and goals may well be critically important determinants of what teachers do and why they do it (Schoenfeld, 1998). In a case study reporting on three mathematics teachers, Thompson (1984) “observed consistency between the teachers’ professed conceptions of mathematics and the manner in which they typically presented the content” (p. 125); in other words, teachers’ beliefs about how mathematics should be learned, appeared to influence how they taught it, irrespective of their expressed beliefs about their instructional practice. In confirmation of this, Cross (2009) found that there was “greater alignment than misalignment between teachers’ mathematics-related beliefs and their instructional practices” (p. 341).

Proficient and up-to-date teachers know and understand the latest teaching/learning theories and trends and are able to function in a digital environment. It appears that such teachers are more positively disposed to use technology in their teaching. So, a strong belief in the value of technology for learning mathematics, coupled with a firm willingness to be open to (new) personal learning could be important factors for teachers thinking about using a digital environment (Thomas & Chinnappan, 2007).

Though it seems quite important that teachers’ have positive beliefs towards technology and educational software, if digital activity is to be a part of the everyday school curriculum (Myers & Halpin, 2002), this may not be enough. The introduction of such tools not only introduces new variables into the classroom, it also changes existing conditions (Barzel, Drijvers, Maschietto & Trouche, 2005). Such issues should be addressed by professional development.

Professional development

Access to computers and mathematical software has increased globally in the past few decades, but in many places like Nepal technology is rarely integrated substantially, or even at all, into everyday teaching. One reason for this is the heretofore lack of appropriate professional development for application of technologies and tools in a classroom situation.

Improving professional learning and development of educators is crucial in transforming schools and increasing academic achievement (Darling-Hammond, Wei, Andree, Richardson & Orphanos, 2009). In the study reported in this paper, it was aimed to address practicing teachers, so Professional Development in the form of in-service workshops was used. 6 A successful professional development program should “provide teachers the opportunity, the time, materials for improving professional practices, [and] assist the teachers in developing creative instructional approaches that are meaningful and mathematically correct” (Taylor, 1986, p. 3). Such approaches should also help them instill enthusiasm in their students. When organizing a professional development initiative for teachers to begin incorporating technology as part of their mathematics teaching, teachers’ existing pedagogical ideas and their needs, expectations, and previous classroom experience in a digital environment should be taken into account. Other key features to consider are a concept of the importance of understanding technology, and skill and practice in a different context than normally used (Compton & Jones, 1998).

Well-structured professional development concerning the use of digital technology likely changes the beliefs of mathematics teachers towards its use, though the beliefs may not

---

6 The term Professional Development refers to comprehensive, intensive, and effective approaches in raising teachers’ familiarity with requisite skills and content they are teaching Knapp (2003).
GeoGebra: A case study of impressions of mathematics teachers in Nepal

change immediately (Guskey, 1986). One success story is a study conducted by Goos and Geiger (2010) who reported that despite teachers’ initial skepticism about the software, participating teachers used technology-supported lessons and introduced significant improvements in their teaching. What is important here is that teachers’ initial impressions and thoughts were different, possibly negative, on the use of technologies before they had professional training, but once they had experienced professional development in these particular areas, they changed their position and began to use the software with their students.

**Effectiveness of professional development**

An important caveat for professional development initiatives was suggested by Guskey (1986): “significant change in teachers' beliefs and attitudes is likely to take place only after changes in student learning outcomes are evidenced” (p. 7, italics original), so teachers are more likely to adopt a different strategy, e.g. teaching a concept in a digital environment, if they have already seen positive results with their students. In addition, teachers are also influenced by their own teaching goals (which may be strongly affected by country and classroom culture), and unless they can perceive a practical value (e.g. perceived fit with the examination syllabus) in using a new skill with their students, they might not adopt the innovation learned about in professional development (Doyle & Ponder, 1977). It has further been suggested that “teachers are more likely to build on what they learn from professional development experiences when their existing knowledge and priorities are acknowledged and made central to the learning process” (Kanaya, Light & Culp, 2005, p. 313).

In the mathematics education field in particular, more teachers should be interested in getting professional development training in the use of advanced technology. However, many teachers seem unwilling to integrate a digital environment despite its importance. This is in part due to their lack of pedagogical experience in using a different teaching/learning environment, but in many countries like Nepal, this may also be due to a fear among teachers that using DGS will be at the expense of student performance on the national examination. Increased knowledge about and skill in using technology combined with positive results in using it with students could help teachers to be more disposed toward incorporating it in their instructional practice.

The issue for those delivering professional development to teachers concerns whether the new skills and knowledge are given an active role in teachers’ classes after the training is completed. Do teachers try new skills and activities with their own students, and further, do they continue to use them after the training has concluded? One way of judging the effectiveness of professional development is whether teachers continue to practice what they have learned. The initiative described in this paper was designed to encourage teachers to do this, though it was not very successful in this aspect.

**The Workshop and Methodology**

Considering the vital role teachers play in a technology-supported mathematics classroom, in many countries it may be a matter of adapting professional development opportunities in order to prepare teachers for this new challenge of effectively integrating technology into their teaching practice (Preiner, 2008). There was previously almost no opportunity provided teachers by the Nepalese government for professional development to enable them to gain some experience in a digital environment; yet there was a clear, demonstrated need to do this. Given the circumstances, it was deemed wise to start on a local scale. The initiative reported here concerned a four day training series using a workshop
format and focusing on DGS (specifically GeoGeobra). Since the group to be trained was small and it was desired to look at teachers’ impressions in some depth, qualitative case study methodology was used.

Aims of the research: The principal aims of the study were to investigate (a) impressions, feelings, and beliefs of the participant teachers concerning the software, (b) technological problems experienced, and (c) teachers’ personal motivation to continue using the software.

Organization and participant details

This research study and workshop was organized with the help of the National Teachers Association (NTA) Kathmandu, Nepal, which contacted teachers working in schools having some computers. Those who were interested applied and were accepted for the training. The workshop series was held in the computer laboratory at a local college in Kathmandu, the capital.

It is worthwhile to mention that there are two types of schools in Nepal: government and private. All participating teachers were selected from secondary government schools which had computer facilities. Fifteen teachers from secondary government schools attended the workshop, fourteen men and only one woman; participants’ teaching experience ranged from 6 to 15 years. Geographically, twelve teachers were from schools in the Kathmandu district, while the other three were from outside the city. Participants were reimbursed for travel, and lunch was provided each day. At the end of the training, all teachers received a certificate to verify their participation.

The Training

The first author took the role of workshop leader and trainer as well as researcher. In addition to demonstrating the software, the researcher also observed and helped participants when they had difficulties working with the computer and/or the software.

The four days consisted of 6.5 hours of training each day for a total training time of 26 hours. The first three days were spent in learning and exploring the software. The final day was devoted solely to working on independent construction tasks suitable for secondary level mathematics. Specific tasks were assigned to help participants explore the software further with the view to help them attain some independence in software use.

Roundtable demonstrations and discussions: Morning sessions (with a laptop and projector) were devoted to learning about GeoGebra. This included functions of various tools and discussion of possible applications with students (Figure 1). Different tools were demonstrated such as menu items, general tools, algebraic input and some command items of GeoGebra with examples. Different aspects of using a digital environment were discussed.
Afternoon sessions in the computer laboratory consisted of hands-on work with the software. Since all computers were installed with GeoGebra, each participant had computer access and could explore tools learned about in the morning session (Figure 2).

On the final day of the workshop participants were assigned specific tasks to construct using GeoGebra and were given as much time as needed to complete their constructions. Once they finished one task, they could proceed to the next one. There were twelve tasks involving secondary school mathematics, designed to cover almost every tool and trick the participants had learned during the previous sessions. By focusing the tasks on secondary
mathematics, the intent was that teachers could use the them with their students. There was ample opportunity for participants to explore all activities.

Content

The focus of the training was to introduce teachers to tools most suitable for teaching secondary school mathematics in Nepal. The training initially concerned basic tools and menu items, but progressed to cover more complex tools. Some examples of content are below.

- General tools and menu items: constructing regular polygons, drawing/working with perpendicular bisectors, reflecting and rotating triangles. Basic menu items also included changing the language of the software by using the option icon.
- Algebraic input and command item tools: these are flexible tools (compared to menu and general items), so a general idea and overview were given about the algebraic input. Plotting a line (e.g. \( x + y = 5 \)), a quadratic equation (e.g., \( y = x^2 +5x+6 \)) and so forth were covered with the algebraic input tool.
- Some ready-made activities were presented to give ideas about how to design and develop lesson materials for use in the classroom. Examples included area and volume calculation of a pyramid, and reflection and rotation of a triangle.

Teachers were always encouraged to observe corresponding changes that appeared in the algebraic window when the object was changed in the graphical window (Figure 3). Throughout the training sessions teachers freely asked questions about points of confusion. More examples were suggested by participants, and these were also explored.

![Figure 3 Screen shot of a GeoGebra window](image-url)
Data collection

Data were collected via a questionnaire, an interview, and field notes of the researcher’s observations. Also some follow-up data were collected via communications with two participants. The instruments used for this study were designed to ascertain three aspects regarding participants: (a) impressions, feelings and beliefs concerning the software, (b) technological problems experienced, and (c) personal motivation. The questionnaire contained open as well as closed questions; it was also designed to collect any additional feedback participants might have. Participants were given the questionnaire on the last day of the workshop and requested to complete it within a week, which they did (13/15 returned). The interview was administered at the end of the last session. The researcher had invited particular participants for an interview, but instead of several individual interviews, participants requested that they give one interview all together, with one designated person among them as the main spokesperson for the group. Participants agreed that these data could be used for research purposes, but on an anonymous basis.

Findings

One of the main aims of the study was to investigate the impressions, feelings, and beliefs of the participant teachers concerning the software. Analysis of the data revealed that all participants had positive impressions of using GeoGebra; they seemed very interested as a group and even expressed enthusiasm. In different ways they also expressed the desire to continue using the software. Participants’ interest was further demonstrated in the form of concentration on task. In the afternoon sessions in particular, participants were deeply engrossed in trying different tools and eventually making their constructions. All indicated that they desired to achieve some degree of expertise with the software. Two examples from the data:

- The least experienced teacher thought that GeoGebra created an easy teaching/learning environment for teachers as well as for students; he also thought that teaching would be easier in future if teachers could use this software. He said he was very inspired to use the GeoGebra software in his own lessons.
- A second teacher (10 years teaching experience) said he never thought or imagined that this kind of mathematical software would be available “free of cost”. He added that this software was really interesting and useful, and that he was very much impressed by GeoGebra because it provided a graphical and algebraic view at the same time.

General agreement was reached by participants that the software was very useful and helpful in providing conceptual knowledge for students because of the interactive capability of the GeoGebra platform. The data showed that all teachers were highly impressed by the software and interested in using GeoGebra in their regular lessons. They indicated their belief that GeoGebra helps to provide conceptual as well as procedural knowledge. There was general consensus that GeoGebra is helpful for meaningful learning, gives actual mathematical concepts, and enhances long term memory of the mathematical concepts.

The second aim was to determine participants’ technical difficulties. Analysis of the data indicate that the majority of the participants had technical problems, some quite severe. Many frequently asked for help from the researcher and peers because they had little or no knowledge about using a digital environment to solve mathematics problems; many also had trouble using basic computer tools other than GeoGebra. Of course, some participants learned more quickly than others.
Analysis of the data indicate that of the 15 participants, only five were able to complete all tasks on the final day. There was a range in participants’ capacity to learn to work in a digital environment, with some struggling to complete a task, while others moved along more quickly. On the final day participants who were able to finish the tasks in a shorter time than expected, then engaged in helping others. Yet there were teachers like one person (nine years teaching experience) who frequently mentioned that he was “very poor” in computer use and requested a follow-up workshop for more practice. Further evidence of a lack of technical skill in working in a digital environment and/or confidence to do so was found in requests from several teachers for the researcher to visit their school “whenever we need help”.

The third aim concerned participants’ motivation. In this small case study it was not possible to separate motivation for learning to use the software from motivation to use it with students, nor was it feasible to collect reliable data on motivation. However, some general findings can be reported here. The eagerness with which participants embraced the training and the tenacity shown in their attempts to become comfortable with the software contribute a positive impression of participants’ motivation to get to a point where they could use it. One teacher (7 years teaching experience) stated that he was highly impressed by the software’s multi-dimensional features. He went on to comment: “I am impressed by the ability of the software that made easier understanding of Pyramid and Transformation. It was complex to teach and verify the concept of the slant height of a Pyramid. Now, it will be easier to explain because of the GeoGebra software.” One of the most experienced teachers clearly expressed his interest and enthusiasm for GeoGebra. He explicitly reported that with GeoGebra, teaching and learning activities would be more interesting and easier, and mathematical problems could be solved practically: “GeoGebra is very useful mathematical software. It helps us to teach mathematics in a practical way. It helps us to understand actual mathematical concepts.”

Regarding long term practice in the use of both skills and knowledge learned in the training, little can be said at this point, though two participants did communicate some weeks afterwards that they had installed the software on both their personal and school computers with the intent to use some of the workshop construction tasks with their students. The study revealed that many participants were interested in using GeoGebra in a real classroom setting as much as possible, but most said they first needed more workshops as follow-up to learn more about the software. Therefore, the data indicate that the four-day workshop did not sufficiently prepare participants nor instill enough confidence for most of them to be able to use the software in their regular teaching lessons.

**Conclusion and discussion**

Though educational software technologies still seem out of reach in many developing countries, this is not the complete story. Important constraints to acquiring and using up-to-date technology are the cost associated with much of the available educational software and, also relating to cost, the lack of internet access, most especially in schools. If costs can be brought down and technology made more easily available, then it may be more realistic to use (Perraton, 2000). In effect, free educational software that can be run, without any or adequate internet access, could greatly enhance the integration of digital environments as part of secondary school mathematics. Clearly for places with many demands on funding beyond expenditure on basic educational needs (teacher salaries, textbooks, etc.), open source software may be worth considering. As an example, GeoGebra can be downloaded on a laptop or external drive and then uploaded to as many school computers as desired, ready for both teachers and students to use. Recent successful initiatives with GeoGebra in two other
countries, Zambia (Wakwinji, 2011) and Ethiopia (Tessema, 2012) involved in training mathematics educators, also confirm these points. One positive development recently is the government of Nepal has begun working on a master-plan to guide the education sector in using ICT as a fundamental tool for effective teaching and learning processes (Pant, 2011).

The way in which teachers approach the use of technology has major consequences for its application in the classroom (Kendall & Stacey, 2002). This study confirms that technical problems could be a critical factor for mathematics teachers in many similar places. However, on balance the more technical skill and knowledge teachers have, the more confidence they will gain and the easier they will find it to integrate digital learning environments in their classrooms. As teachers become more confident in a digital environment, they can focus more on how the environment could work with students in their own discipline.

The Dynamic Geometry Software (DGS) environment is essentially intended to improve the learning of mathematics by creating a context in which sense can be made of mathematical activity (Gutiérrez, Laborde, Noss & Rakov, 1999). To enable teachers in this, basic skills and knowledge of computer use are essential in order to work with dynamic software like GeoGebra successfully. When teachers arrive without such background or experience, the consequence for professional development is that the training must begin at this basic level. As in this study, participants who are already beyond the basics can then become co-contributors to the training of those who are not. However, to build sufficient confidence to use DGS with one’s own students requires extra support and training, as requested by a number of the participants.

**Limitations of the research**

In a country where having digital skill is not the norm, even among educated people like teachers, numerous small but important details emerge in any training session involving computer software use. This can be as basic as learning to turn on a computer and start a software program, or failure to realize that clicking/double clicking a button activates a tool or menu item. In this study, only one participant came with his own laptop; it is simply not the norm at this time to possess one, or even to know someone from whom to borrow one. It is to the participants’ credit that they did not let such problems hinder them in trying to learn and enter a digital environment. However, for a lone researcher and software trainer in a workshop, it is difficult to obtain enough detailed data for close analysis. One is almost completely taken up with trouble-shooting, helping new users, often individually, and answering the many questions. A video camera was not available at the time of this research; it would have been very helpful towards data collection. Field notes were kept, of course, but some points would have benefited from further verification, either by an independent observer (one knowledgeable about the software and mathematics education) and/or a video record. This situation must be improved in future.

**Concluding remarks**

Teachers in this study showed positive impressions and were motivated to learn to use GeoGebra, but most were not ready to integrate it in their mathematics teaching. These findings are similar to those reported earlier by Wu, Hsu and Hwang (2006): positive impressions and attitudes are simply not sufficient for teachers to be able to integrate a digital learning environment like GeoGebra in a mathematics classroom. Improving teachers’ PCK to include technical skill and knowledge, and doing this through professional development combined with some local support, appears to be the way forward, particularly in the context of countries like Nepal. With appropriate training and some networking among themselves,
we believe that Nepalese teachers would become confident enough to try GeoGebra in their teaching. Once they saw some positive results with their students, it is more likely that they would continue to use it (Guskey, 1986; Cross, 2009).

Despite numerous constraints and difficulties, use of GeoGebra in Nepalese secondary schools does appear to be feasible. An earlier study (Mainali, 2008) has indicated that it is possible to implement DGS (GeoGebra) for teaching mathematics at secondary school level in Nepal (Figure 4), but the training must be in place for teachers to adapt its use in their teaching.

![Secondary pupils working on a GeoGebra activity (Mainali, 2008)](image)

**Figure 4 Secondary pupils working on a GeoGebra activity (Mainali, 2008)**

Before attending this workshop, participants of this study had *never considered* the possibility that mathematics could be taught *unconventionally*, for example by using interactive (DGS) software. Given the general perception of mathematics as a rather dry subject, participants were highly impressed by the visual features of GeoGebra; they described this visual feature as a very useful tool for practical mathematics learning. In sum, the positive impressions, feelings, and beliefs shown by participants further validated the potential use of DGS environments in Nepal. These training efforts will be continued in future.
GeoGebra: A case study of impressions of mathematics teachers in Nepal

References


