TEACHING, LEARNING AND TECHNOLOGY IN THE PHILIPPINES

BARRY KISSANE
Murdock University
Australia 6150
B.Kissane@Murdock.edu.au
http://www.staff.murdock.edu.au/~kissane

The attraction of technology for mathematics education is that we may have new opportunities for students to learn and teachers to teach. This paper describes some recent examples of technologies that seem likely to be appropriate for use in the Philippines, and analyses the merits of their potential. Particular attention is paid to hand-held calculators because they are the most likely to be affordable and available, when resources are scarce, as they often are in the Philippines. Additionally, some computer software with particular strengths is acknowledged: spreadsheets, which are likely to be widely available where computers are available; Geogebra, free software that has substantial geometric and other capabilities; Fathom and Tinkerplots, innovative commercial software for statistics; digital objects such as Java and Flash applets focused on particular teaching and learning tasks. The Internet offers considerable potential for mathematics education, despite the relatively high costs of obtaining access to it, and seems likely to grow in significance in the Philippines in the next several years. A typology of ways in which both students and teachers might productively use the Internet is presented and defended. The paper concludes with some comments on directions and standards for technology in the Philippines, and a recognition of the pervasive significance of professional development of teachers.

Introduction

The past two decades have seen a great deal of interest in the role of technology in school mathematics education. Some have even suggested that it is one of the most important forces driving curriculum change, as well as a powerful force in the everyday world of schools, teachers and their students, although such claims of course depend on the circumstances of schools, including the economic circumstances. While there is considerable diversity in both the Philippines and Australia, it is clear that resources for schooling and thus realistic access to technologies differ markedly between our two countries. Filipino readers of this paper will need to decide for themselves which technologies deserve the most attention.

In this paper, we examine some of the ways in which developments in technology open fresh opportunities for teaching and learning in schools. The focus is on opportunities that are not readily accessible without technology. Necessarily brief, the paper draws heavily on previous work of the author, in which the details of the educational arguments are provided. Some different kinds of technology are briefly described and their potential contributions to mathematics education in the Philippines analysed.
Examples of Technology

Calculators

In recent years, calculators have become much less expensive and consequently widely available in the community as well as in schools. There is a suite of calculators available to schools, with varying levels of sophistication, depending on the age and mathematical maturity of the students. Calculators are an especially important form of (electronic) technology, as Kissane (2007) noted, offering the following educational arguments for their use:

1. They are easily portable, and so can be easily shared in a classroom or a school, used in different classes, and even used at home.
2. They are less expensive than computers, especially when all the software needs are taken into account (as calculators contain their own software).
3. As they are potentially more accessible on a wide scale to students than are other forms of technology, curricula can be designed on the assumption that students can access technology.
4. They can be used in formal examinations, which are of considerable importance in many educational settings. This advantage is mostly a consequence of the preceding reason.
5. Most of them have been designed, and modified, for the express purpose of school mathematics education, and so are sensitive to the needs and interests of students and teachers.

These arguments seem at least as valid in the Philippines as they do elsewhere. Experience in Australia has suggested that allowing (indeed, expecting) students to use technology in important examinations has a very significant effect on the availability and classroom use of technology. Most (but not all) parts of Australia now permit the use of graphics calculators in high stakes examinations at the end of secondary school, with many now moving towards the use of calculators with computer algebra systems.

Kissane (2007) suggested that, while calculators (as their name suggests) have a potential role in computation in school, they have other roles as well. Most importantly, they offer students the chance to experiment with mathematical ideas for themselves, and offer teachers the opportunity to engage students in active mathematical work for educational purposes. For example, student exploration with elementary calculators can help them to see the structure of the decimal number system and the relationships between fractions, decimals and percentages. Scientific calculators offer more sophisticated opportunities, many of which are explored in the Casio ES Series Project (2005), which has downloadable materials. This is a new way of thinking about learning, and not merely an exercise in using a calculator to avoid learning how to do arithmetic by hand, as some still seem to think.

While elementary and scientific calculators offer some new learning opportunities (especially the more sophisticated scientific calculators), there is an explosion of opportunities offered by providing students and teachers access to graphics calculators. The availability of a graphics screen,
and inbuilt calculator software to use it productively, shifts the focus of the graphics calculator away from calculation and towards experimentation of many kinds. There are many examples of this kind of affordance described in Kissane (2007) and very many more contained in Kissane & Kemp (2006). There is not space here to outline more than a few of these opportunities.

A graphics calculator allows students to readily construct, manipulate, study and use graphs of functions. Such activity can help students to see relationships between functions and their graphs, functions and equations, graphs and their parameters and data and models, in ways that were previously not possible. They also allow students to explore other mathematical objects, such as matrices, sequences, series and complex numbers. While scientific calculators allow students to perform statistical calculations, graphics calculators allow them to undertake data analysis, choosing from a range of alternative ways of dealing with their data, and also to undertake elementary inferential statistics. The combination of random number generation and data analysis allows students to explore the use of simulation as a mathematical tool. Data logging add-ins allow calculators to store and analyse real data collected by suitable electronic sensors. Recent calculators have also included other mathematical tools, such as a spreadsheet, a financial mathematics package and dynamic geometry software, widening yet further the suite of opportunities. Kissane & Kemp (2006) provide many examples of how these sorts of capabilities can be used to explore mathematical ideas. As noted above, the design of graphics calculators for educational use (rather than other kinds of use) has lead to the development of modern machines that potentially impact on essentially all parts of the secondary school curriculum. As a recent example (Kissane & Kemp, 2008) describe in some detail how the teaching and learning of calculus can be affected by access to a graphics calculator.

In addition to facilitating student computation and allowing them to explore mathematical ideas, the availability of calculators raises questions about the content and the balance of the mathematics curriculum. For example, young children using calculators regularly will soon find that negative numbers appear when a larger number is subtracted from a smaller number. Middle years students will find that their calculator prefers $2\sqrt{2}$ instead of $\sqrt{8}$. Older children will find that quadratic equations always have two solutions, although sometimes they need complex numbers to express them. They will also find maximum and minimum values of functions directly from graphs. Senior students will find that they can solve equations and evaluate integrals to any sensible level of precision, even when they cannot find exact solutions to problems. Students of statistics can focus attention on the meaning of statistical ideas and on data analysis (using their own real data), rather than being restricted to hand computation with ‘nice’ numbers. In these and many other ways, access to technology forces curriculum writers to reconsider what is fundamental to mathematics (and why), and what ought be reconsidered in the light of technological tools used by students. Both what is regarded as important in school mathematics and the sequence in which ideas are encountered are affected by access to calculators.

Computer Software

In some Filipino secondary schools, computer laboratories are available, permitting students
to use computers, while in other schools, a classroom may be equipped with projection facilities, allowing the whole class to see the screen of a single computer at the same time. Both settings offer new opportunities for both students and teachers. Of critical interest is the software used on the computers.

Spreadsheets are often available as part of a suite of software (such as Microsoft Office), and offer a range of opportunities for students to explore mathematical ideas. Although not designed for educational use, spreadsheets can be exploited for educational purposes. By their nature, spreadsheets are particularly helpful for some kinds of mathematical modelling, handling data sets and for studying recursive relationships, although there are many innovative ways in which teachers have used them for mathematical purposes as well. Especially for teaching older students, a good source of information about the use of spreadsheets is the (free) electronic journal, Spreadsheets in Education, maintained by Bond University (2009).

A good example of recent versatile software specifically designed for educational use is GeoGebra (2009). As its name suggests, this software links geometry and algebra; recent versions have included several other elements, including a spreadsheet, statistics, calculus and images, all of which can be dynamically manipulated for a wide range of mathematical purposes. Dynamic linking of objects and environments leads to many opportunities, including the construction of interactive objects that can be opened by a web browser and thus shared between teachers and students or teachers and teachers. GeoGebra also allows users to directly enter and manipulate equations and coordinates. Thus they can plot functions, work with sliders to investigate parameters, find symbolic derivatives, and use powerful inbuilt commands. A large (and rapidly growing) user group internationally contributes to discussions about the development and use of this software, with many interesting examples available for download and use from a GeoGebra Wiki page. The fact that the software is in the public domain is likely to be important in countries like the Philippines, where resources at the school level are often very limited.

While commercial computer software can be expensive, especially if a copy is needed for many computers, some innovative software designed for educational use is worthy of special consideration. In the area of statistics, Tinkerplots and Fathom, both produced by Key Curriculum Press (producers of The Geometer's Sketchpad) use the idea of dynamic geometry in the environment of statistics, allowing students to explore their data in powerful and creative ways. Software of these kinds provides students with the tools to undertake data analysis on real questions that interest them, rather than merely computing some numerical statistics. Evaluation copies of these are available on the web for short-term use by teachers, and a rich library of suitable activities has been developed by the publishers to illustrate the potential changes in ways of thinking about statistics.

Another potentially useful species of computer software involves small applets, often with a single educational purpose. These are typically written in Java or Flash and made available via the Internet, which is discussed in more detail in the next section. Applets can be downloaded by teachers (or by students) for exploration, and require only a browser, with appropriate (free) plug-
ins to work. They can then be used in situations in which 'live' Internet access is not available. This may be a mechanism for teachers in the Philippines to begin to explore the potentials of this kind of software, when resources are constrained and Internet access is limited. In some cases, such as the NRICH site in the UK, and the Maths Online site in Austria, teachers are both encouraged and helped to do so by the site itself, so that only minimal technological skill is needed to do so. In other cases, such as the excellent National Library of Virtual Manipulatives, inexpensive copies of applets can be purchased on CD-ROM. A very useful website of Math Tools (Math Forum 2009) offers advice, help, examples and wide discussion of applets such as these, as well as other kinds of software.

The Internet

The Internet, while a very recent development, has now become an everyday part of many societies, and not only those in affluent western countries like Australia. All schools in Australia have connections to the Internet and, increasingly, teachers and students have reliable access in their classrooms. In addition, many students (around two thirds) have reliable and fast access to the Internet at home, even if the realistic access at school is limited. However, there is a considerable range of facilities in Australian schools, and the new federal government has identified the need to improve this situation as a key part of its proposed 'education revolution'. A recent Australian development involves the construction of a national curriculum for the first time, with mathematics being one of the first areas. The framing paper, highlighting the intended directions, has made it clear that digital technology is to be embedded into the curriculum, rather than being regarded as an optional extra, which will provide further stimulus for developing access to the Internet as well as other ICT facilities in schools.

It is clear that this description does not match the situation in the Philippines, although it is also clear that this is a time of rapid change, both in homes and in schools. (For example, Filipino home Internet access is rapidly increasing, it seems, for some demographic groups.) It seems appropriate to consider the particular opportunities that might be afforded by the Internet, even if these are not yet as readily accessible in schools as they are in more affluent countries. At the least, this might offer advice regarding the suitability of investing scarce resources in developments of this kind, with an eye to setting goals and standards.

A recent analysis (Kissane, 2009) identified and illustrated six categories of potentially productive use of the Internet by students. For each category, a separate rationale was developed, highlighting the distinct advantages of Internet use of that kind. The author maintains a website, accessed from the web address above, which contains annotated descriptions of many good examples of publicly available websites in these various categories; interested readers are referred to this website. There is space here for only a brief description for each of the six categories, drawn from the site: (i) Interactive resources; (ii) Reading interesting materials; (iii) Reference information; (iv) Communication; (v) Problem solving; and (vi) Webquests.

Interactive resources: These allow students to interact directly with mathematical objects,
in a variety of ways. The experiences provided are very difficult to provide in other ways and engage the students directly in mathematical activity and a corresponding need to think about what they see on the screen. Resources of these kinds can be used by teachers with the whole class as well as by students, and downloaded for offline use in some cases, as noted earlier.

Reading interesting materials: There are many interesting materials related to mathematics on the Internet, in sharp contrast to many school libraries, where these exist at all. Some materials intended for the general public are suitable for students, especially older students, and there are also good materials written expressly for students. Such material may kindle interests in mathematics that would otherwise not be sparked by more conventional school experiences. Many materials in this area can be regarded as concerned with the public understanding of mathematics or 'popular mathematics'.

Reference information: The Internet has been likened to a massive encyclopaedia, and can be used as a means of looking up various kinds of mathematical things for various purposes. These might be used by students from home, especially as few homes will have a mathematical reference source such as a dictionary or encyclopaedia. They might also be used in school, by both individual students and teachers or by a whole class.

Communication: The Internet offers opportunities for students to communicate with other students or teachers, regardless of geographical location (but limited to those speaking the same language). For Filipino students, some opportunities to be part of a wider mathematics community are provided.

Problem solving: While a great deal of 'problem solving' ought to happen in regular classrooms, the Internet can theoretically offer some extra benefits to students, including a regular supply of suitably targeted problems, opportunities to share solutions and even opportunities to get professional feedback on their work. There seems little argument for a set of problems on the web that could just as easily be written in a textbook, with nothing else added.

Webquests: These are activities in which some or all of the information that students need comes from resources on the Internet. In the case of mathematics, these usually take the form of a guided exploration of a topic, requiring students (or usually groups of students) to undertake some web-based research and to generate a product of some kind (such as a report). Most of the available examples are located in a particular cultural context (especially the USA), so might best be regarded as offering ideas for development of similar materials for the Philippines.

It is clear from perusing some of the examples linked on the website that there are now very many opportunities provided by the Internet for students to engage in productive mathematical experiences that were not previously accessible to them. While it is (very) expensive to design good examples of these kinds, and the examples chosen are restricted to those in English, the allocation of resources to this task in many countries means that quality materials have been developed and generously shared with others. It seems rational for these to be made available for teachers to refer
their students to, rather than relying on either students or teachers browsing for materials themselves, as there are many low quality materials on the Internet as well, and much time and resources can be wasted.

Unsurprisingly, research on the effective use of resources of these kinds, and the consequences of their use, is still to be done, made difficult by the rapidly changing environments in which they are located. However, a perusal of the above website will reveal that there are many raw materials for such research now available on the web for mathematics educators to use and to study.

As well as materials for students to use, the Internet also holds considerable promise for mathematics teachers themselves. Of course, mathematics teachers are, by the nature of their profession, interested in high quality materials from which students can learn mathematics and about mathematics, but the Internet for teachers is not restricted to that dimension. A recent analysis by the author (Kissane, 2009) has suggested six categories of use of the Internet by mathematics teachers. As for student use, this analysis has an accompanying website, accessible from the home page above, and a process of illustrating good examples has begun. The six categories are: (i) Lesson preparation; (ii) Official advice and support; (iii) Professional engagement; (iv) Commercial activity and support; (v) Local school web sites; and (vi) Mathematics teacher resources. Again, space allows only a brief description and rationale of these categories:

Lesson preparation: Many teachers have been prepared to share their successful lessons with teachers elsewhere. There are inevitable differences in style and in the cultural and curriculum constraints under which teachers work. However much is to be gained from the experiences of others, and it seems likely that teachers will share only their best lessons. Hence many lesson collections contain excellent ideas for teachers, to support planning their own lessons for their own curricula in their own contexts. Of course, many lessons available in this way may not suit the needs and interests of Filipino teachers with particular classes, so that discretion is needed.

Official advice and support: Teachers everywhere work within a framework determined to some extent by external constraints, either at the state or national levels, and sometimes both. Official advice on the Internet is easier to update, although harder to print, than written materials, and is becoming common. It can also be helpful to see what is offered outside one’s own environment. This allows access to external advice and also a sense of perspective on how curricula are varied from place to place, including being supported in different ways.

Professional engagement: Professional associations at national and local levels offer the most efficient and productive ways of professional engagement. While local associations (such as MATHTED) are generally of the most immediate relevance, much is to be gained by using more distant associations as well; this of course includes associations concerned with research and development in mathematics education. Some professional associations offer very substantial help to mathematics teachers, not restricted to members only.
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Commercial activity and support: Many companies that develop and distribute materials (such as textbooks and software) for mathematics education maintain web sites to support both their customers and also prospective customers. Some of these offer exceptional levels of support and help for teachers, not only those who use their products, including classroom materials as well as technical materials. Demonstration software and other opportunities to sample commercial products are also offered, providing rich opportunities for understanding new possibilities for good teaching.

Local school web sites: Increasingly in affluent countries, mathematics teachers use a school website to support their teaching, providing they have sufficient expertise with the web in order to do this efficiently. Much of this activity is often local to a school (through an intranet) not visible to outsiders, of course. It is helpful to see some of the ways in which school websites have been used for various purposes connected with teaching, necessarily restricted to "public" versions of websites. A key role of school websites may be to communicate the school's work to a wider community audience, which may become important in the Philippines as Internet access grows. Looking at other school websites may be helpful to teachers responsible for their own school web site.

Mathematics teacher resources: This category is intended to capture websites that don’t easily fall into only one of the other categories, but offer a range of ways of supporting the work of mathematics teachers, including the provision of various kinds of resources (materials for students, videos, posters, reviews, applets, news items, etc.). There are some excellent resource collections of these kinds in various countries, with many materials on them of potential benefit to Filipino teachers.

By its nature, the Internet is a shared and democratic resource. While there are certainly commercial uses of the Internet (many of which are quite beneficial for education), it is important to recognise that it provides many opportunities for mathematics teachers to address the final three aspirations outlined in the Announcemen for this conference: identify appropriate approaches that can be utilized in the mathematics classroom for students at different levels; help mathematics educators to promote understanding, interest, and appreciation of mathematics; and serve as a venue for sharing that could contribute to an improved mathematics education in the Philippines and throughout the world.

The challenge of making use of these resources effectively is not an easy one, however, even in countries with considerably more economic resources than those in the Philippines. There is a significant need for professional development and support of teachers, as well as attention to the role of technology in pre-service education. Providing the technological resources, while necessary, is not sufficient to making effective use of them in schools.

Directions and Standards for Technology

In considering directions and standards for technology in the Philippines, it is important to think carefully about the purposes for using technology in mathematics education. Of course,
technology should not be used just because it has become available. Rather, attention should focus on the many ways in which today's technology might be able to improve student experience of mathematics and seem likely to help students learn better. Some of these mechanisms focus on the idea of student experimentation with mathematical ideas and objects, facilitated by technology tools. When resources are limited, as they often are in practice, it seems wise to orient the use of technology to activities that cannot be done well easily without the aid of technology. Whether at a school or a national level, when choosing from a range of technologies, it is critical to consider issues of student access: the best technology is that which all students have the opportunity to use. Technology that is accessible only to a few students is unlikely to have a significant effect on the curriculum for all students.

As always, it is important also to acknowledge the critical role of the teacher. Designing good activities and implementing them effectively in classrooms are important roles for teachers. To make effective use of technology in mathematics education, teachers need personal access to suitable technologies, they need help to integrate the technology into their classrooms and they need a curriculum that accommodates the use of the technology. None of these three requirements is easy to meet in practice. For example, sound use of technology can easily be undermined by a curriculum or an examination setting that does not recognize appropriate use. Advice on professional development is provided by Kissane (2003), suggesting that teachers using technology progress through a series of stages, and that the professional development support needed varies between these stages. While this advice is pitched at the use of graphics calculators, it seems likely that it might be used to support setting standards and directions for professional development for other technologies as well. Setting standards and directions for the use of technology in the Philippines will not be a useful exercise unless careful attention is paid to the teachers who are ultimately responsible for implementing these.

Conclusion

In 2000, the National Council of Teachers of Mathematics in the USA espoused its technology principle: “Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning.” This remains a useful principle, and summarises very well research and development and professional activity of recent years. However, it is necessary to recognize that the implementation of such a principle in the Philippines (or in Australia, or anywhere else) must take place in a cultural and economic context. So, while it is important to learn from others, it is even more important to interpret the work and perspectives of others in our local contexts.

Technology does not teach: teachers do. Similarly, students don't learn directly from technology: rather, they might learn from what they do with the technology. For these reasons, professional development of teachers is a critical component of the process of both setting and implementing standards and directions for technology use in the Philippines.
Further, attention should focus on how to improve student experience of mathematics, as these mechanisms focus on the use of concepts facilitated by technology. This is a natural evolution wise to orient the use of these enablements towards the goals of technology. Whether at the institution or the classroom, it is critical to consider how teachers have the opportunity to use. This can have a significant effect on the teaching and learning of the teacher. Designing personal access to suitable technology is important for teachers. To achieve this, they need access to classrooms and they need a clear plan of their three requirements is easy to determine by a curriculum or professional development. It is important to progress through a series of stages between these stages. While this might be used to support learning, it will not be useful for supporting professional development as well. Setting goals of this nature is not a useful exercise for implementing technologies as well. Setting addressing the needs of the mathematics curriculum in the USA espoused its use in supporting mathematics; it influences student performance. It remains a useful principle, and an influence of recent years. However, there is no evidence of the use of hand-held technology in the Philippines or in any of the other Asian countries or in the United States. As such, the work and perspectives of future developments don’t learn directly from this experience. For these reasons, it is important to consider the process of both setting and implementing the technology.

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References

[Note that papers by the author are accessible at http://www.staff.murdoch.edu.au/~kissane/papers.html]


