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## Getting school maths online: Challenges and possibilities

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## **Getting school maths online: Possibilities and challenges\***

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The World Wide Web (WWW) is making a significant impact in the field of mathematics education. In recent years, several thousand web sites have been created to promote the teaching and learning of school mathematics. It is now time to ponder how this phenomenon should articulate with the school curriculum and how the wealth of resources available in cyberspace can be appropriately integrated at the classroom level. This paper discusses a range of instructional, curricular and organisational issues associated with such a process and provides recommendations for future research.

### **Introduction**

As early as the 1930s, Shoghi Effendi predicted the imminent arrival and expansion of the World Wide Web (WWW) with these words: 'A mechanism of world inter-communication will be devised, embracing the whole planet, freed from national hindrances and restrictions, and functioning with marvelous swiftness and perfect regularity' (1936, p. 203).

Several decades needed to pass before this vision became reality. The WWW can be now considered as a computer network made up of literally millions of users worldwide. The last decade has attested to a substantial transformation in the way knowledge has been traditionally disseminated. Through WWW technology, information now flows almost unrestrainedly throughout all the regions of the globe and easily reaches homes, centres of learning and remote village settings. The speed of this process accelerates as the globalisation processes dramatically unfold. So amazing has been this information revolution that educationalists have been forced to consider its effects on education. What we need to consider, as we progress into the third millennium, is how to harness the potential instructional advantages of the WWW for the benefit of classroom teaching.

### **Reasons for online approaches in mathematics education**

Several arguments can be put forward to advance the cause of teaching and learning mathematics through online approaches. School curricula need to evolve in line with the changing nature of our society. The WWW is similar to other important landmarks in the evolution of the school mathematics curriculum such as the invention of the hand-held

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calculator and the personal computer. Given its increasing and indispensable presence in human affairs, the WWW must be reflected in the school curriculum if that curriculum wishes to remain relevant. The nature of the WWW is such that it offers an enormity and diversity of resources that are, for the most part, free for access and download. These resources have the advantage not only of being recently created but also produced and shared by field practitioners such as teachers, academics, instructional designers and even students themselves. The range of resources has the potential to broaden the spectrum of students' learning experiences thus enriching the mathematics curriculum. Resources available online are also suitable for distance education where students work at their own pace and at any geographic location. Online resources can also be repackaged and redesigned as, for example, thematic units linking school mathematics to real-life situations. Moreover, the WWW is a free-platform technology which makes it a friendly-user mechanism going beyond regional technical specifications. It is above all, a wonderful window to the world that can be opened with a single mouse click in the isolation and remoteness of the school classroom.

### **Categories of online resources**

For the purpose of categorisation, resources available on the WWW for teaching and learning mathematics can be grouped into six inter-related categories, namely: drills, tutorials, games, simulations, hypermedia-based materials and tools, and open-ended learning environments (Alessi & Trollip, 2001; Handal & Herrington, 2003). Drill-and-practice websites mostly present exercises for practicing well-structured mathematics operations. Drill-and-practice formats also evaluate the correctness of students' answers once a set of questions have been attempted. Online tutorial applications are one step ahead of drill-and-practice formats in that the former teaches respondents the procedure for reaching the solution. Online instructional games allow students to participate in an entertaining situation that simultaneously demands their engagement in problem solving at several levels. Online simulations are applications that interactively model or fabricate a real-life situation whose enactment in the classroom is impractical or even hazardous. Hypermedia software, in turn, are complex databases of several kinds of mathematical knowledge linked through nodes of information. Hypermedia formats can be compared to electronic encyclopaedia covering a broad range of topics such as history of mathematics or mathematics vocabulary. By providing cross-curricular content, hypermedia resources are an ideal environment for exploration and investigation. Finally, the WWW also offers tools and open-ended learning environments that can be used for representing data graphically, experimenting with geometrical concepts through interactive diagrams, or drawing complex curves given their equations. The sequence of formats outlined above can be considered as a continuum that progresses from an instructional design that favours the independent, transmissive drill-and-practice approaches through to tools and open-ended learning environments that facilitate a collaborative, problem solving approach.

The organisation of resources into a virtual classroom is probably the most fascinating example of the WWW's potential in education and training (Anderson, 2001; Murphy & Collins, 1997). Virtual classrooms place a community of learners together under the leadership of one or more instructors using several online facilities such as video-conferencing, electronic boards or electronic discussion groups. This online learning approach has been known as synchronous learning since students can learn simultaneously regardless of location. They can also make use of asynchronous formats

such as email and downloaded materials. Virtual classrooms are becoming popular in adult training and are progressively making their way to the school environment.

## Issues in online mathematics education

The growing presence of the WWW in education will undoubtedly reflect the way the curriculum is conceptualised and organised. An important discussion should focus on how online learning experiences are aligned to a constructivist perspective of teaching and learning mathematics (Lefrere, 1997). Such an articulation must certainly reflect the pedagogical worth of instructional approaches such as group work, discovery learning, problem solving, real-life situations, in-depth discussions, use of manipulatives, field work, and so forth. Vargo (1997) explains that the constructivist approach in computer education also includes the student having more control and access to information, the use of more discovery learning and explorations as well as the introduction of more case analysis. That approach stands out in clearly contrast with an objective or behaviourist model, in which the user only receives and replicates information. Nunan (1996) adds that flexible delivery through online methods fosters a culture of self-learning, problem solving, and activity-based learning. According to Winn (1997) the following principles apply to a constructivist approach in WWW-based teaching and learning (p. 2).

- Access to the Information Superhighway is not a sufficient condition for learning, though for students in distance learning programs, it may be a necessary one.
- The information that we prepare for students comprises data to which we give a structure that is determined in no small part by the medium in which the information is presented. This structure will be influential in how students understand what we tell them.
- The acquisition of knowledge from information requires effort and involves perceptual and cognitive processes that decode symbols, deploy literacy skills to interpret them, and apply inferencing abilities to connect them to existing knowledge.
- The acquisition of wisdom from knowledge requires practice in the judicious application of that knowledge in the personal and social context in which the student acts.
- By implication, testing just to see whether a student has received information, which is not atypical even in higher education, sheds absolutely no light on what students really know nor on whether they can productively use any knowledge they have acquired.

In brief, a constructivist approach to mathematics and online education envisions a learning community in which learning activities are carefully selected to assist students in constructing knowledge. These activities must also take account of students' previous experiences. The constructivist approach also considers the teacher not as the only knowledge provider but as a learning facilitator who supports active learning. This role includes the provision of learning activities through interactive online technology.

The utilisation of online resources in the teaching and learning of school mathematics may come with a number of instructional, curricular and organisational challenges. As the literature on the field is nascent more research is needed to guide online educational endeavours. The following represents a collection of those issues which ideally must be analysed within the context of the six categories of online resources described above.

The WWW is a relatively new learning technology. Certainly, little is known about its cost-effectiveness in comparison to other instructional approaches. Likewise, more research is needed to determine its effects on students' attitudes towards the learning of

mathematics. It is also important to identify instructional practices within the classroom leading to students' gains in achievement as they work with online learning resources. Similarly, there is a need to examine whether current online learning approaches lead to a decrease or an increase in the gap between high and low achievers. Likewise, the type of social interaction, either among students or between teachers and students, that is generated while working with these resources requires further examination (Clark, 2000). Research is also needed on the impact that WWW technology has on broadening students' learning or cognitive styles and teacher's instructional styles.

Literature generated in the last two decades shows that teachers' pedagogical beliefs about educational innovations can sometimes work against the implementation itself (Handal, Bobis & Grimison, 2001). In particular, negative beliefs about the introduction of technology into the classroom have been documented by Newhouse (1998) and Mills and Ragan (1998). Consequently, it is necessary to characterise current teachers' beliefs about the worth of online instruction. Likewise, there is a need to examine parents' and school administrators' perceptions about online instruction so that potential obstacles can also be foreseen. At the same time, students' perceptions of online learning need to be appraised with respect to motivation to learn and engagement in learning.

The WWW offers a variety of applications that can be considered problem-solving tools. They include applications to solve arithmetic, algebraic and differential equations, curve drawing and graphical representation of data. It is possible that educators could see some of these tools as a process of deskilling. Alternatively, assessment items can be written to accommodate the use of these tools in such a way that reflects the measurement of students' higher order thinking capabilities. Assessment criteria would also need to be re-formulated to distinguish measurement of students' actual mathematical understanding from their navigational skills.

In addition, a number of issues will inevitably arise as a consequence of the increased access of the WWW both at home and at school. Should the whole curriculum or parts thereof be aligned to the utilisation of online resources? How should literacy skills, discovery, case analysis, inferring and other higher-order thinking abilities will be taught and developed in online learning approaches? Which novel learning competencies such as navigational skills, webpage design, computer architecture or applet programming, need to be taught to better utilise online resources? Do these new competencies mean that the curriculum could become overcrowded? If that is the case, which current content should be removed from the curriculum?

Current research reveals that boys are more engaged than girls in computer studies and do better in some aspects of mathematics (Kifer & Robitaille, 1992; McDougall, 2000). Hence, it can be argued that these gender-related trends might also be reflected in the learning of mathematics using online resources. Similarly, it is reasonable to question whether children from low-socio economic backgrounds will be disadvantaged due to their lack of access to the WWW, particularly after school hours (Hartmann & Sweeney, 1999). It has been argued (Navin, 2001) that private schools, particularly from more affluent sectors of society, have an advantage over public schools given the disparity in the investment in educational technology. In a futuristic situation, where WWW learning has a greater presence in the curriculum, it is likely that textbooks will be modified and adjusted accordingly. Textbook writers, curriculum designers and classroom teachers will also need to pay more attention to cross-cultural issues such as differences between imperial and metric units, language barriers and international events, among others. For example, learning to add by counting elephants would not sound very relevant to Australian Aboriginal students in the outback or South American children in the Andes highlands.

Not only is there a lack of literature about using online resources in the teaching and learning of mathematics, there is also a scarcity of specialists in the field. Although both human resources and research will inevitably grow hand-in-hand, the urgency of the hour demands that resources and practical guidance be provided to classroom practitioners. This raises a further set of critical questions to be addressed. Should the leadership come from academics, regional or district consultants, or school head teachers? How should classroom teachers' experiences be shared and extended? Teachers' networks, peer mentoring, inservices, teacher education programs, university partnerships, showcase of best practice, all need to be developed and documented to fulfil a comprehensive support structure for professional development.

The use of the WWW enables the use of a further set of related hardware and software technologies such as data projectors, printers, laptops, data loggers; it also raises issues such as having the classroom connected to the Internet, and of course, the purchasing of appropriate computers. Management and maintenance of the school Intranet is another associated cost as well as the school licensing of more sophisticated software. Likewise, the task of searching the WWW for identifying meaningful learning experiences is certainly time-consuming and demanding for teachers (Godfrey, 2000). Setting up either a personal or faculty database of relevant websites adds considerably to teachers' workloads, particularly when such a database is to be arranged by grade, curriculum area or degrees of difficulty.

Despite its unique advantages, the WWW can be depicted as a disorganised and sometimes misleading pool of unrelated websites. When it comes to educational websites many of them are of poor quality in terms of instructional design, being little different to traditional textbook formats, and being developed by people involved in commercial software (Lefrere, 1997). It is therefore vital to focus our education agenda on issues such as: how many of people involved in the production of current online resources are actually educators and capable of developing something for education purpose? How should teaching education programs begin establishing courses on online instructional design? What makes a website educationally sound? What can be learned from the literature on evaluating computer-assisted instruction (CAI) software that can be applicable to online resources? (Hosie & Schibeci, 2001). Which guidelines in evaluating online resources are worth considering? How can teachers be trained to assess the quality of educational websites? Which quantitative and qualitative research methodologies are most appropriate in the evaluation of educational websites? For example, Hosie and Schibeci (2001) and Reeves and Harmon (1994) have called for more context-bound evaluation rather than checklists because the former captures a lot more of the interaction between the learner and the courseware.

On the effectiveness of WWW-based instruction, Scanlon (1997) reviewed online learning in sciences and found that teachers are more inclined to use traditional resources such as books than the Internet. Scanlon noted a number of concerns on evaluating courseware online such as bandwidth, network reliability and integration of the curriculum with technology. Simons and Jones (1999) evaluated the Online Mathematics Enrichment website in the United Kingdom ([www.nrich.maths.org.uk](http://www.nrich.maths.org.uk)) which provides support for gifted and talented students through the publication of problems and other resources. The evaluation of the program with 450 teachers and 199 students was 'judged to be attractive, functional, easy to navigate, and contain high quality materials' (p. 11). According to the evaluators, 'The main impact of NRICH on the more able students was in terms of helping them to gain a wider appreciation of mathematics and raising the profile of mathematics as a subject that could be interesting enough to pursue either within or outside school or for further study' (p. 11). Indeed, more research is needed to explore the implementation of online approaches in teaching and learning mathematics.

## Conclusions and recommendations

Not surprisingly, as with any educational innovation, the introduction of WWW resources in the teaching and learning of school mathematics comes with possibilities as well as challenges. The instructional, curricular and organisational issues outlined in this paper, although not comprehensive, serve as a discussion board for future research and planning. The lack of studies in this nascent field is hindering the utilisation of a vast number of online resources that are already available for classroom use; and yet, the WWW is developing at an increasing speed, not waiting for the school curriculum to catch up. Crucial and urgent to this dissonance is the commitment of the academic community to become engaged in more research in this area. Like a third millennium's version of *Pandora's box*, the WWW is waiting for us to open it and to discover its marvels in this era of globalisation. Hopefully, as educators we can harness its potential benefits rather than succumb to possible chaos.

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