Predicting the Future – Training Teachers for Tomorrow

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Abstract

> "Who of us would not be glad to lift the veil behind which the future lies hidden; to cast a glance at the next advances of our science and at the secrets of its development during future centuries? What particular goals will there be toward which the leading mathematical spirits of coming generations will strive? "

So said David Hilbert as he looked at the mathematical landscape at the beginning of the last century, in an age before the certainty of uncertainty had tainted mathematical thinking and the dream of a coherent mathematics was thought attainable. These remarks are echoed by mathematics educators at the start of this new century when they contemplate the potential of the new technologies to change the way in which the subject is taught and are forced to analyse the very nature of mathematics itself. This paper will examine some of the difficulties facing teacher educators in mathematics as they struggle with predicting the future.

Introduction

As Hilbert stood on the cusp of a new century he gave what was perhaps the most influential speech given to mathematicians, by a mathematician about mathematics [1]. He had a great vision for a coherent pure mathematics and laid out his famous problems to challenge the mathematical community. Research in pure mathematics has exploded in this last century and the mathematics community has been forced to grapple with the idea of uncertainty as an integral part of mathematical study and accept the fact that the vision of Hilbert may be beyond our reach for good. New areas such as chaos embrace uncertainty and demand that we live with it. As Stewart [2] puts it in reply to Einstein's famous quotation *"it is not so much **whether** God plays dice but **how** God plays dice"*. People are beginning to question some of the fundamental ideas of mathematics and are forced to re-examine the basic tenets of mathematical research.

Educators of teachers can empathise with the sentiments of Hilbert as it seems that they being asked to "*lift the veil behind which the future lies hidden*" and "*see the secret of its development during future centuries*" – or at least decades, as they attempt to prepare students to be teachers for many years to come. In parallel with the pure mathematics community it often feels in mathematics education that the only thing we can be certain of is uncertainty, as we know that fashions come and go and that the style of teaching currently in vogue will be denigrated in years to come. Like everyone else in education we have been subject to the winds of change concerning teaching methodology and changing emphasis on methods. Questions such as: "Didactic versus child-centred?", "Subject based curriculum or skills based curriculum?", "Calculator-friendly or calculator-free? " have taxed the minds of mathematics educators through the years. The most important skill we can equip our students with is the skill to cope with this change and to integrate new ways of thinking into their practice.

This paper will look at the current situation with regard to technology in mathematics education and argue that at the moment technology is seen as a useful tool standing outside our curriculum and that the emphasis is on personal competence of teachers rather than training them to incorporate ICT into their teaching. It will then argue that for technology to be an effective aid in the mathematics classroom we must look at how it affects the mathematics curriculum and produce a coherent vision for the future.

New Technology

The debate about methodology is not new but has been given an urgency, as we stand on the edge of our new century, by the increased pace of change wrought by new technology. Teachers have at their disposal a wealth of technology and just as one gets to grips with one aspect, for example, laptops in the classroom, another, for example, interactive whiteboards, comes along introducing further challenges. Teachers trained to teach in the traditional classroom are being encouraged to develop their personal competence in using the new technology but not necessarily how to use the new technology to teach. The difficulty appears to be mainly in the integration of this technology into our classrooms and finding a balance between the skills required to operate the equipment and the higher skills required to adapt one's current teaching to make best use of the equipment. This idea that technology is an "add on" to what we do normally in the classroom is echoed throughout the literature.

The BECTA Curriculum Software Initiative Report: Mathematics [3] which looks at the software that might be required in schools comes with a major warning on the competence of teachers to use such software effectively and cautions that teacher inexperience is still a problem.

In 1999 a report on the use of ICT in primary schools commissioned by the Teacher Training Agency [4] supports such a claim. It states that teachers generally use ICT as extension work and as a reward for those who have completed other work with the least common use being direct instruction. Much use of ICT in primary classrooms was planned as an addition to the curriculum rather than a key teaching strategy. In addition most schools identified pupils' capability in their regular planning but did not specify how ICT could contribute to subject teaching.

This apparent inability to fully integrate the technology into the classroom is not confined to the primary (under 11 years of age) sector but can be evidenced in the post-11 sector too. The annual surveys of Information and Communications Technology in Schools carried out by the Department for Education and Skills [5] provide a useful comparison as well as a picture of the changes in the last few years. In 2000, 48% of mathematics teachers in the secondary sector made substantial use of ICT while in 2001 the figure had risen to 60%. The comparable figures for teaching mathematics in the primary school are 66% and 74%.

In Ireland a recent project called Dissolving Boundaries involved schools from both the primary and secondary sectors. They were given communication equipment, including video-conferencing equipment, and were linked with other schools. The aim was to use ICT to promote quality learning in schools and to enable the pupils from different parts of Ireland to develop a better understanding of one another through working together on curriculum based work. In the report [6] produced at the end of the project it was felt that while the project had met most of it criteria in terms of linking schools and allowing students access to such technology the nature of the project in most schools appeared to be an extra curricular activity. Rather than influencing teaching strategies, using ICT in learning or impacting on the curriculum it was seen often as an after school activity or something to be done as a "time filler" towards the end of term. These schools had teachers and student teachers who were proficient users of the technology but the problem again appeared to be in the integration into the existing curriculum.

The Core Content

It is clear then that technology has had limited impact on existing methodology in the mathematics classroom. If we are struggling with questioning *how* to teach mathematics then how much more so are we unwilling to examine the impact of technology on *what* we actually teach. While the great debate about method of delivery has been raging in education as a whole those in mathematics education who design the curricula have lived in a cloistered world where certainty remains a safe refuge. While attempts have been made at A level to introduce new modules such as decision mathematics and course

work at GCSE has shifted the emphasis slightly the vast majority of what we teach remains unchanged. Ideas such as Pythagoras' theorem as it was 2500 years ago, is now and forever will be or the calculus as it has been for the last 300 years or so are the cornerstones of our mathematical faith which form the basis of most mathematical curricula throughout the world. There are of course cultural differences in what exactly constitutes this core but such a detailed discussion is beyond the remit of this paper.
In Figure 1 below we see the current situation with technology not impacting the core but being combined, sometimes effectively, to lead to improved teaching. The common core is not questioned or justified. We attempt to teach it as it stands using the new technology available to us.

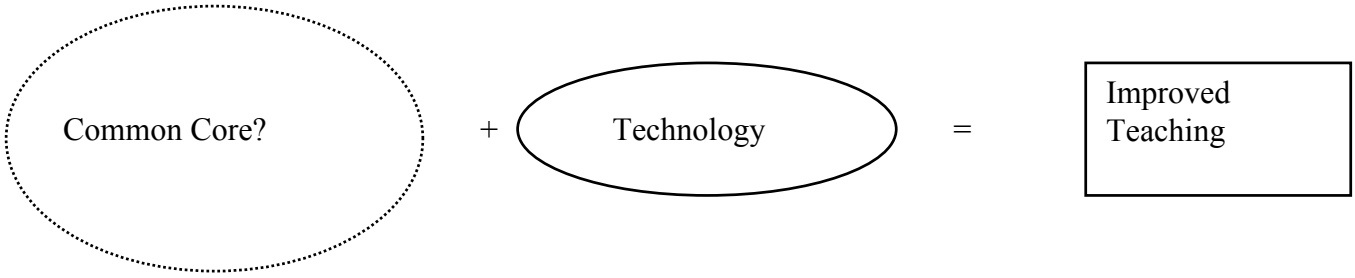

Figure 1 Current Situation with regard to New Technology

During recent times we, the community of mathematics educators, have entered the debate concerning technology with the aim of finding ways to use it to teach this core in a more coherent, effective manner. This is of course a very important question and is naturally the initial reaction to any new technology – how can it be used to support the existing structures? As discussed above, most of the literature produced to date on this subject has been approached from this perspective.

Looking to the Future

However the time is coming when we must be brave enough to examine our central tenets in mathematics and ask not just **how** we can teach our existing curriculum better but **why** do we teach what we do. Should we be teaching this central curriculum as it stands or does our new technologically advanced society demand that our children are equipped with something different? Even if we come to the conclusion that this core is sacred and should be taught with the help of technology rather than revised I still feel that it is a question worth asking. When confronted with the question "Why do we teach what we do?" the answer " Because it has always been so" is no longer a satisfactory one. We should be prepared to defend the mathematics we teach with something stronger than historical imperative. In Figure 2 we see the two overlapping and together leading to our goal of improved teaching. As described above this overlap does not necessarily imply that we **must** change what we teach but it allows the discussion to take place and we open ourselves to that possibility.

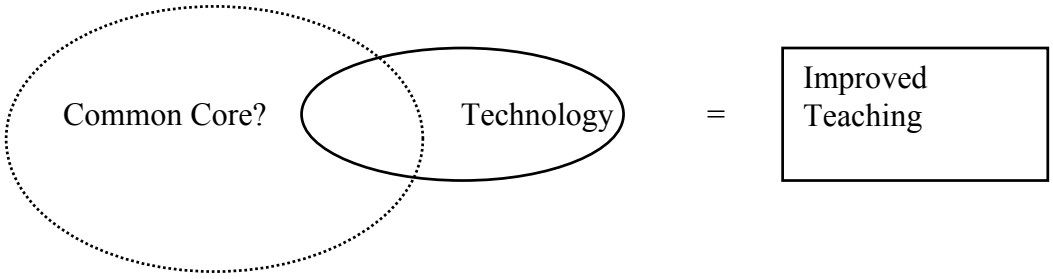

Figure 2 The New Model

The last time that technology impacted on the curriculum to at least some degree was in the 1970s with the introduction of calculators to the classroom. There was certainly a debate at the time concerning the continuance of teaching pencil and paper methods of calculation when the technology was readily

to hand. In fact this debate continues still as a recent US paper entitled Let's Abolish Pencil-and-Paper Arithmetic [7] shows. Here Ralston argues for a rethink of the curriculum in elementary schools. While one may not necessarily agree with his conclusions he at least challenges us to think again about what we have for so long considered sacred. Here in Britain at primary level there is evidence to suggest that the influence of calculators is limited and Ruthven [8] suggests that there has been no real redefinition to take account of the calculator. The only main impact of the calculator on the curriculum, as opposed to on methodology, seems to have been in the secondary sector where logarithms lost their place as a major tool for calculations and are now relegated to something useful with which to draw certain graphs.

While we have managed to keep an intact curriculum that largely ignores the calculator this position is becoming increasingly difficult to justify as ever more advanced technologies make their way into the classroom. Computers are certainly playing a role and perhaps if we move to a stage where laptops are freely available then we will have to take greater cognisance of their presence. But it is from our old friend the hand-held calculator that the greatest challenge comes. While computers are still expensive and not readily available in every classroom for every child the new breed of calculators is becoming cheaper and ever more powerful. The computer symbolic algebra software now available on these machines is capable of integration and differentiation – two of the cornerstones of A level mathematics - and thus far our response has been to ban them from the examination rather than to re-examine our specifications. Other countries take a different view and in parts of Australia graphics calculators have been used in public examinations for a number of years - see for example Forster [9]. Much more research needs to be carried out in this area in the United Kingdom to find out just what impact these machines are having in our schools.

The responsibility lies heaviest on the shoulders of teacher educators. If we miss the opportunity to produce teachers who can cope with changing methodology and changing curriculum content, if we produce teachers who don't appreciate the importance of what we teach and who can't integrate the content and the technology but see them as diametrically opposed, as seemed to be the case in the 1970s, then we are doing a grave disservice to our profession and sowing the seeds of doubt about the usefulness of much mathematics for many generations.

Conclusion

Undoubtedly technology will and in some respects is changing the *way* that we teach. We must answer the question that it poses about *what* we teach. If we initiate the debate we can trust the strength of mathematics to withstand the onslaught of existing, and as yet unforeseen, technologies and emerge stronger and sure of its place in the future education of our young people. It is not a question of choosing between ICT and mathematics rather of learning to combine them effectively. The cause of mathematics is not served by avoiding the hard questions about the role of technology but by confronting them and answering them with conviction so that we have a subject knowledge for the 21st century delivered with the technology of the 21st century.

References

1. Hilbert, D, (1900), Mathematical Problems, Lecture delivered before the International Congress of Mathematicians at Paris.
2. Stewart, Ian, (1989), Does God play Dice? , Penguin Books Ltd.
3. British Educational Communications and Technology Agency (BECTA), (2000), Curriculum Software Initiative Report: Mathematics.
4. Moseley, D. et al, (1999), Ways Forward with ICT: Effective Pedagogy using Information and Communications Technology in Literacy and Numeracy in Primary Schools. Newcastle, University of Newcastle.

5. Department for Education and Skills (DfES), (2001), Survey of Information and Communications Technology in Schools 2001.
6. Kinnear, H., Caul, L., McWilliams, S., Dunn, J., McAlister, M., Eaton, P., Dissolving Boundaries through Technology in Education, (2001), Stranmillis University College, Belfast.
7. Ralston, A., (1999), Let's Abolish Pencil-and-Paper Arithmetic, Journal of Computers in Mathematics and Science Teaching Vol.18, No.2 173-194
8. Ruthven, K. (2001), British Research on Developing Numeracy with Technology, Teaching and Learning Primary Numeracy: Policy, Practice and Effectiveness, 28-32, British Educational Research Association in conjunction with the British Society for Research in the Learning of Mathematics
9. Forster, P., Mueller, U., Outcomes and Implications of Student's use of Graphics Calculators in the Public Examination of Calculus, Int. J. Math. Educ. Sci. Technol., 2001, Vol. 32, No. 1, 37-52