Whither Goes Technology

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Abstract

The author describes the current scene of the use of technology in schools and tertiary institutes, and gives his personal views on the use of technology in mathematics teaching and learning. In short, he put forth his conviction on whither technology goes.

1. The current scene

The milestones in mathematics education, as identified by one former ICMI president, are: Euclidean geometry, calculus, and abstract mathematics. If identified now, they could have been: Euclidean geometry, calculus, and technology. Indeed technology is here to stay, to grow, and to be an integrated part of mathematics.

In fact, technology grew very rapidly in a short span of time. I taught numerical analysis in 1965 using mechanical calculators with levers. Now we use scientific calculators, that is, electronic calculators with scientific functions. They are standard regardless of brands. The cost of a scientific calculator now is 5% of what it was 30 years ago. Also for computers we have progressed from punch cards to on-line. FORTRAN and AGOL were the common computer programming languages. Then we talked about structured programming, introducing PASCAL. Now there are many other languages including Visual Basic and C-programming.

The power of computers was to be able to compute numbers very fast. Symbolic manipulation was difficult due to its demand on storage space. Due to the advances in hardware, it is now within reach. The common mathematical software are MATHEMATICA, MAPLE, and Scientific WorkPlace among others. They can perform most of the operations required in calculus and linear algebra. They are powerful tools for the user of mathematics. Most recently, technology has gone beyond numerical computation and symbolic manipulation and it serves as a means of communication through facilities like internet and multimedia.

There is a major change of culture in the work place. Desktop computers and notebooks are commonly used. We must train our students for the new environment. We cannot wait. The question is not how many we can train but rather how many we would miss training if we do not start now. In the past the hardware has advanced much faster than the software. I believe the hardware will reach its limit sooner than the software. It is the use of software that will be the main focus in the near future.

In Singapore, technology is moving into schools in a rather aggressive way. Now all schools are provided with computers, locally developed software to be played on VCD, and very soon local materials on the internet. However it is not an integrated part of the curriculum yet, though it will come in due course.

2. My conviction

Time will tell whether my conviction will become reality. Since they tend to be subjective, I can describe them at best as my conviction.

(1) Use open tools.

We have adopted one computer algebra system (CAS) for all year one mathematics students at the National Institute of Education (NIE), Singapore. What we want is a CAS which can draw graphs and manipulate symbols. It does not matter what CAS we use. I am not in favour of my staff writing software for teaching. Like learning a language, we should use basically one dictionary and keep using the same one. In the same way, we should encourage the use of a single software tool initially.

I believe, as far as the use of technology is concerned, the same strategy should apply to schools. We should encourage the use of open tools. By open tools, I mean something generic which can perform certain functions though they may not be designed to serve any specific purpose. How useful the tool is depends on the user. Even at the primary level we may wish to keep to a limited number of open tools. If the past experience is anything to go by, getting plenty of CD-ROM may be exciting initially. It is something generic that will last.

(2) CAS before computer programming.

There is a debate on whether students should learn computer programming first or CAS. I choose CAS before computer programming as an entry point for our students at NIE. We need more car drivers than mechanics. We need more people who know how to use the software than to create them. I recall in early days to learn computing we would start from number systems base 2 and base 16. Later we still had to write our own programme if we wanted to solve a cubic equation. There are so many software packages available now. Like shirts most of us buy ready-made and no longer go to a tailor. That should be the norm. For most of the users, probably there is no need to learn computer programming. CAS will grow and will become more powerful and sophisticated. It will also become more friendly, and more people will be able to use it without being experts in computing. In short, we should go for CAS and reserve computer programming for the specialists.

(3) Technology helps make mathematics more explicit.

Technology helps to do numerical computation and symbolic manipulation. It can also help to introduce mathematical concepts. This aspect of the technology is not fully recognized. A common weakness of our students is to be able to solve a problem but not to be able to write it down. To use technology we have to make explicit the procedural steps required. This is helpful in the learning process. So we should use technology beyond its ability to compute numbers and to manipulate symbols.

(4) More time spent but richer return.

It is a fallacy that technology can save time and money. In fact, it does not and it actually requires more time and money. The reason for using it is that we are now able to do things which otherwise are not possible. Therefore when we infuse technology into teaching and learning of mathematics, we should look into the areas where technology could play a significant role so that the use of technology is not merely a transfer from overhead transparencies to powerpoint presentation. In other words, it should be an enhancement and not a replacement.

(5) Mathematics is an experimental science.

It is said that if a mathematician makes a statement, in the western tradition he will be asked to prove it. In the east he will be asked to use it. This is not exactly true. It does carry one message that mathematics is more of an experimental than an exact science, especially with the availability of technology. Pure mathematics was a late invention. This is the part, namely the rigour of the subject, we want to keep. However it was the experimental aspect of mathematics that helped the discipline to grow. With technology we should teach mathematics in some way as an experimental science.

(6) Infusion of technology into curriculum must be done in steps.

New initiative often failed because we rush it. though infusion of technology into curriculum is our ultimate goal, this is not our first step. In order to be successful, we must prepare the teachers and prepare the students. The first step is simply to use it and it does not matter where and how we use it. The next step is to use on all occasions whenever feasible. It is the final step that we try to infuse fully into the curriculum. Eventually we use it when appropriate, and we no longer talk about when to use or when not to use technology.

(7) The power of technology is a myth.

There were many predictions as what computers were capable of. They did not come true, for example, in the field of artificial intelligence. There is always a limitation when technology is concerned. In scientific computation, for a really large problem or a local singularity not easily visible, often it is mathematics that plays a more crucial role than technology in solving the problem. Hence we should be constantly aware of the limitation of technology. We use it but with caution.

(8) Computers and calculators are converging.

It is an issue whether we should encourage the use of graphic calculators. We should not be misled by the name. In fact, graphic calculators can also perform certain symbolic manipulation, for example, matrices. To use or not to use, as I see it, depends on how fast computers and calculators are converging. Indeed they are converging. Most people think that there will still be a while, say at least 5 years, before the two are comparable if ever. If so, then the use of graphic calculators would still be desirable say at the senior middle school level. Calculus is taught in schools as if it were algebra and not analysis. Perhaps the use of graphic calculators may help to adjust somewhat the flavour of calculus being taught at the school level.

(9) Graphic is powerful and not fully explored.

Virtual reality never fails to fascinate the viewers. It has been used to great advantage in industry and in medicine. It has not been used much in teaching and learning mathematics. This is also part of geometry though a different kind of geometry. At a more elementary level, it does not seem meaningful to spend so much time teaching curve sketching in calculus when this can be done easily using CAS or graphic calculators. Now we do not learn long multiplication at the primary level, and we do not learn finding the square root of 2 at the secondary level. Similarly, with the powerful graphic tool available there are things that we no longer need to learn and there are also things that we can now do and that were not impossible previously. Indeed this has not been fully explored.

(10) Communication through technology.

IT means information technology and to some it means instructional technology. We say IT and not computers because it is more than the use of computers in the classical sense, which is basically addition and multiplication of numbers. Previously, distance learning means mail correspondence. Later it could mean through television or video. Now it means internet. It is a powerful tool. We are advancing to a scriptless and wireless society. By wireless I mean we access the internet without having to plug in. We are going beyond technology in mathematics. This set us thinking whether teaching mathematics should consist of only lectures and tutorials.

3. Whither

Whether my conviction above will ever become reality, we can foresee that technology is going to play a major role in education and particularly in mathematics education. There will be many software programmes, CD-ROM etc etc available in the market. Many will be shortlived though a few will survive. Every new machine will have more facilities built-in than the previous one. Very soon we shall need only one standard machine that will probably serve most if not all purposes and not as it is now several machines with various accessories. Then as it goes on there will be special-purpose machines, like walkman in the music industry whose sole purpose is to play music from a tape only. We may not see windows, currently the dominating operating system for personal computers. Application software may be web-based and hence it reduces the requirement for bigger and bigger hard disks. There will definitely be unexpected new development. The undergraduate mathematics will have to change, its contents and its mode of delivery. For example, being able to compute real integrals as an application of complex variables is no longer exciting as it was before. In turn, it will put new demand on technology. To meet the challenge, technology will have to advance further.

When we discuss technology, there is always the social aspect of the problem. Computers are still expensive. Though the situation may change. A good example is the telephone. The introduction of handphones allows countries like China to make telephones easily accessible to a large population in a short span of time. The issue here is not whether the developing countries can affort it. Rather it is whether they are well prepared to take upon the opportunity when it comes. I have confidence that it will come.

In conclusion, technology has gone far beyond merely computing numbers. It manipulates symbols and it provides a new mode in communication. Its use is no longer restricted to scientists or engineers. It has become common place in offices, and it has become a culture. Hence in education, and particularly in mathematics education, there is no way we can avoid using technology. Hence we have to accept it, use it, and later put demand on it so as to improve it further. We have to implement it in stages. First, use it for some purposes; then for all purposes. Finally, infuse into curriculum. We have to keep in mind that technology is a means to an end where the end is mathematics.

References

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