Flexible learning in mathematics: the future

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To understand the future, we must first understand the past?... I am writing this article in personal style, as it is based on the invited talk I gave at FLIM (Flexible Learning in Mathematics) 2000, the Mathwise User Group's annual conference, which took place in Birmingham in September. I hope that style will be seen as appropriate for the MSOR Newsletter, which provides a wonderful vehicle for members of our community to "talk" to each other.

The title suggested by the User Group was "*Flexible Learning in Mathematics: the Future*". When I heard this I just said that was fine, but then had time to repent at leisure. I am not clairvoyant and even less likely to be so when change is occurring at the current scale and speed.

I therefore begin with an apology for a title which perhaps claims a little too much! I did however wonder whether by taking a broad look at where we are now, and how we got here, we could learn something about the direction to try to take in the future. Hence the "quote" at the beginning of this article, although of course for every quote, we can find something similarly wise, which contradicts it: "*Telling the future by looking at the past assumes that conditions remain constant. This is like driving a car by looking in the rearview mirror.*" (Herb Brody). Ho hum.

I shall be taking a positive, constructive, even naively idealistic stance, although as a former Mathwise author I hope I am able to be "honest" about that particular package without offence, as any criticism applies at least as much to me as to others. I shall also state the obvious in places, but I do think that is a useful thing to do sometimes.

I interpreted the brief in broader terms than just discussion of the future of Mathwise, to encompass the whole area of flexible learning in mathematics, which was indeed the title of the conference. The Mathwise User Group is more than aware of the "competition" and the need to be aware of the rapid developments elsewhere, for instance in mathematics on the web.

I was trying to raise questions in order to provoke discussion rather than impose my own answers, although I suppose it is a politician's trick to make one's own point of view clear by asking the right questions!

Some big issues facing the HE Mathematics community

We are all aware of how wider issues can affect the way that learning and teaching develops in our subject. Sticking to the strategy of stating the obvious, it is perhaps worth rehearsing some of these issues here, to set a context for the rest of the article.

At a time of widening access to HE in general, we face the seemingly contradictory problem of difficulties in recruiting to mathematically based courses (although numbers of applications to BSc Mathematics courses are holding steady overall).

We face greater diversity in the academic backgrounds of our new students, partly because of changes in school mathematics, and partly because of a wider variety of entry qualifications.

We find many students arrive at university lacking *confidence* in mathematics. Not only this but we now find variable levels of *motivation* to study mathematics (or indeed to study at all!), with many distractions including the

need for most students to have a paid job as well, simply in order to keep the wolf from the door.

Within this difficult and rapidly changing context, there has also been a steadily declining unit of resource over a period of time, and a more business-driven approach to management, with devolved budgets (frequently devolved deficits!). Arguments such as "a university without a mathematics department is unthinkable" cut no ice with this kind of mentality, and so a consequence is that a number of mathematics departments and courses have been and are closing (list them yourself), and others are feeling the threat.

The phrases above are perhaps heard so often that they become a mantra, but I believe it is worth chanting them occasionally to remind ourselves that all of these factors are important enough to have to influence the way we decide to go in the future.

It is tempting to think that the rapid rate of advance of technology for supporting the learning and doing of mathematics can provide a partial solution to the problems raised by the context. This may indeed contain a grain of truth. It may be so that technology and the flexible approaches that it allows, and possibly demands, can help. However, developing robust, flexible technology-supported approaches sets some serious challenges, for instance:

- How does one use technology *appropriately*, maintaining the human touch where necessary?
- How can student needs be diagnosed reliably and, equally important, how can their needs be followed up *suitably*?
- Is it possible to use technology and flexible approaches to make the study of mathematics more attractive to as wide a range of people as possible? (We may need to analyse later what we mean by "attractive".)

Using technology appropriately

To help understand what we mean by using technology appropriately, it is perhaps best to ask ourselves "Why are we working on flexible approaches?". Some possible answers may seem cynical here, but it is as well to understand our motivation, in order to begin to sort out what we think may be best for the job. Pick one or more answers from the following:

Answer A: because people have given and will give us money to develop flexible approaches. I must confess that my motivation to become involved as a Mathwise author came at least in part from the prospect of raising a little money; there was of course more than that, but the prospect of money for a new computer is a powerful motivator.

Answer B: because we are enthusiastic and committed people who enjoy solving technical and other problems. It is easy when solving a technical problem to get so close to it that you stop questioning why you were solving it in the first place.

Answer C: because we believe it is a better way to educate mathematically. The measure here is whether practice, in the classroom with students, is actually changing as a result of development projects such as Mathwise.

Answer D: because the world is moving on technologically, and we do not want to be left out. Perhaps neither do we want to look old fashioned to our potential students, most of whom are steeped in technology every day.

What are we developing flexible approaches for?

Perhaps another way to approach the matter is to ask for whom we are developing flexible approaches. Once more there are a variety of answers here, some perhaps more acceptable than others.

It may be that there is a desire to reduce class contact with students in order to reduce costs. There is a certain style of management which clings to the belief that flexible approaches are equivalent to reduced costs. Whatever the contrary evidence, the question was certainly asked about this when the Mathwise project funding was granted.

It may be that we need to deal with perceived shortcomings of our students when they arrive at university, so that we don't have to change our courses too much. Once more a major thrust of the Mathwise project was to help "bridge the gap" between school and university.

However, to be a little more positive, it may be that we believe that university mathematics education can be improved by adding flexible approaches to our range of teaching approaches. We genuinely wish to place our students at the centre of the learning process, taking account of where they start from, aiming to wean them from dependency, and we believe flexible approaches can help with this aim.

Can we learn any lessons from outside the HE mathematics community?

There is commonly, at best, a determined ignoring

between the HE mathematics community and the mathematics education research community. Those who follow some of the email debates in the USA find that even this best is sometimes not achieved. However an extra impetus and status seems to have been given to teaching and learning recently. Perhaps this is encouraged by events such as the demand that all HE institutions must have an explicit teaching and learning strategy, or by the simultaneously demanding yet tedious subject review, or by the fact that three of the recent national Teaching Fellowships were awarded to mathematicians. I am not sure whether to mention the ILT here, as I see it as an opportunity to raise the status of teaching, but some colleagues are less positive.

Be that as it may, the relationship is being re-examined. Indeed one of the working groups at this year's Undergraduate Mathematics Teaching Conference (UMTC) considered exactly what the mathematics education community can offer university mathematics. (As an aside it is worth saying that the push for more status for teaching and learning has not yet led to a surge in numbers attending UMTC, and the conference committee continues to try to understand this. Why not think about coming next September, when the conference is in Birmingham for the first time!)

An observation may not be out of place here. Some mathematics education research is esoteric and jargon-ridden (some mathematics research is not immune to this!), and therefore not much use to us unless either we learn the restricted code of that world, or someone translates it into English for us. Perhaps, though, this should not close our eyes to the potential for using educational ideas to improve the way we work with students (as indeed some people already do); for example the robust evaluation of what we do, or the understanding of the many and diverse ways that students come to learn (or fail to learn) mathematics.

Another world that we may or may not have bumped into is the generic staff development community. It can be tempting to reject out of hand those who do not understand our subject area, but the hackneyed phrase about the baby and the bath water springs to mind.

This community peddles a variety of insights which may be useful when deciding how to continue to develop flexible approaches. The concepts of deep, surface and strategic learning (Marton and Saljö, 1976; Biggs, 1987) have already featured in other articles in the MSOR newsletter. The Honey and Mumford analysis of learning styles, categorising pragmatists, theorists, activists and reflectors, provokes thought as well as reminding us that not all students learn in the same way and that it therefore behoves us to take account of this.

One also finds the occasional gem which can stop you in your tracks, and make you reflect on what you are doing:

> "*Learning is done BY people, not TO them*" (Race, 1994)

> "*Effective learning materials are more to do with designing appropriate learning activities than writing down content*" (Gibbs, 1994)

Finally I note that I haven't even mentioned industry, where most of our students end up.

So where does this section leave things? It was interesting that during the panel discussion at the conference, one of the most impassioned contributions from the floor expressed a considerable degree of hostility towards those who theorise too much about learning. But perhaps, as Lenin said, we can help them to raise theory to the level of practice.

What are we learning about flexible approaches?

I cannot pretend that this is anything like a survey of research: it is an unashamed gossipy report of a talk at a conference. I shall present here only a selection of unpublished findings on student reactions to use of Mathwise (and similar packages) gleaned from unit evaluations at my own institution and elsewhere.

In general, students want lectures! They express the need for human contact and the chance to talk about their mathematics problems. They reach their understandings within a social context. Many students will not go to use a CBL package such as Mathwise unless you structure exactly how they should use it, and stand over them. Many students admit to button pushing in an unengaged way. Many students print out all the screens so that they have "notes".

These reactions may be cultural, but it certainly seems that students in general arrive at university with a clear image (gleaned perhaps from the television?) of what a university education consists of, and they resist counter-images.

Some interim thoughts

It seems from all the rambling paragraphs preceding then, that "educational technology" is about much more than making machines do what you want. It is also about how students relate to those machines; it certainly seems clear that one approach cannot fit all, and therefore no single package can take over the world.

Finally in this section I shall raise two problems relating to multimedia courseware, which we must address in the future.

First, technology for *doing* mathematics moves on (CAS, TI-89, etc), the way people "do" mathematics moves on, and the mathematics that people do also moves on. Updating multimedia packages is expensive, so we must be aware of the danger that the material in them will become ossified and outdated.

Second, it is worth asking the question of how learning controlled by a computer can contribute to producing reflecting, critical, thinking learners.

It may be that progress in developing flexible learning environments more in the style of TI-Interactive or Studyworks stands more chance of addressing these points.

Diagnosing students' needs and following up

Moving on now, the diagnosis of students' educational needs is an important issue, but there are matters which need sorting out. What message do we send with our diagnosis method, what is it actually possible to diagnose robustly, and what is the appropriate way to follow up the diagnosis?

Quickly passing the matter of the message which may be sent by wrongly handled diagnosis (you can come on our course, but you are deficient?), in the next paragraphs there are some propositions for discussion.

Root causes are hard to diagnose by machine (is failure to do a question correctly a basic manipulative skill deficiency, a fundamental lack of understanding at an earlier stage, lack of confidence, lack of motivation, etc?), and students initially find it hard to diagnose their own needs. The least confident need the most human support, not a computer screen, and motivation comes from people.

Following up properly demands we evolve our practice, but even if we thought we knew what is the best way, could we afford it, as flexible approaches are not a cheap option? Again even if we thought we knew what is best, would it just be the enthusiasts who would change?

There are then staff development issues in moving to flexible approaches but there are also management issues: if as the jargon says we are to be facilitators of learning and not "only" lecturers, how are these hours to be counted in work loads? Finally there is the question of how to deal with negative student and fellow staff perception, and university managers with a different and less benign agenda!

Making mathematics more attractive

If we do not succeed in the aim of making mathematical sciences attractive to study then we will not have any students to worry about. If we are changing our practice to be more flexible, then achieving this aim must be a goal. We must also articulate our personal views of what "attractive" means - is it useful, relevant, likely to lead to a good job, intellectually stimulating, fun, what else?

It is our job to make it clear why we need mathematically competent people. As Australian Peter Jones said recently in Beirut, "We must educate for the students' futures, not our pasts". What do our students do afterwards? Do our aims differ from theirs? What are universities for now? What image do we as mathematics departments have in schools? How can the possibilities of a more flexible approach help with this?

Indeed can a more flexible approach help develop the *full range* of what a mathematician is (healthy sceptic, problem solver, modeller, human being, etc) and not just the technical skills?

In the end the future depends on our ability as a community to share good practice (there is a critical MSOR Network role here), share more but value diversity and innovation, be brave with innovation and learn openly even from failure ("*success has many parents, failure is an orphan*"), speak with a more united voice, and keep our mathematics departments open!

References

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