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A teacher perspective on successful ICT use in secondary Mathematics teaching

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At the start of a wider project with a regional group of secondary schools, we asked the core subject departments of English, Mathematics and Science to talk to us about examples, grounded in their own classroom experience, of what they regarded as successful use of ICT to support teaching and learning. From this evidence base we built a model identifying and organising the main ideas expressed by teachers. We think that such a model is of interest because it indicates the concerns of practitioners and captures an aspect of their expertise, refined through their accumulated experience in a range of school conditions. Here we will offer an overview of the model, focusing on the ideas expressed by Mathematics departments. A much fuller report dealing with all three subjects is available (Ruthven, Hennessy & Brindley, submitted), as well as the report of an earlier pilot analysis focusing specifically on Mathematics (Ruthven & Hennessy, 2002). Across the core subjects, several major themes emerged from the departmental accounts of successful computer use. Each points to important ways in which teachers considered that the use of ICT tools and resources could support teaching and learning.

Effecting working processes and improving production

Teachers pointed to ways in which use of ICT could expedite and – more broadly – facilitate the more routine components of classroom activity, increasing the productivity of pupils and improving the quality of work they produced, allowing them to be carried out more quickly and reliably, with greater ease, and to higher quality:

> We've used spreadsheets... to enable them to look at handling data, because they can quickly get tables and produce charts that are much better quality than those that they can produce themselves. I've got the bottom set... and it can take them the whole lesson to draw a bar chart. So it's particularly successful from that point of view.

Comments emphasised the "speed" or "ease" of ICT-supported procedures. Such use of ICT was "time saving" and "kept the pace going". Other comments noted how "reliable" and "accurate" ICT-supported procedures were.

Further comments revealed a range of uses of ICT tools in "carrying out investigations that it wouldn't be sensible to do with pencil and paper", notably using spreadsheets or graphing technologies, and as coursework projects:

> I've… [used] Draw commands in Word for a bit of coursework… where they have to … show their strategy for moving… counters [around], and I did it with a low ability group, and we got far better results I feel, because I showed them how to draw circles and get the sizes right, fill them in different colours, and then once they'd set up the basic grid they could copy and paste the whole grid however many times they wanted, and then they just moved the individual counters around, and as a result of that they did far more work than with the old style of always drawing them out.

Supporting processes of checking, trialling and refinement

Teachers pointed to ways in which use of ICT could support various processes of checking, trialling and refinement. There was positive comment on courseware – commercial or teacher-devised –

which presented sequenced items to pupils, testing them at each step to provide "feedback immediately on how they're doing", and "giving the kids a chance to check their work, because they can't go to the next step unless they get the first question right". Equally, there was approval for the use of calculators and spreadsheets to check the results of calculation and graphing already done 'by hand'.

Such computational tools were also used more interactively to support strategies of problem solving through 'trial and improvement' in which conjectured – often estimated – solutions were repeatedly tested and modified accordingly until acceptable. In a related type of activity, a number pattern or graph was pre-programmed and pupils were challenged to "try and spot the rule by choosing different inputs and seeing what the outputs are", with the computer enabling pupils to "check [a proposed] rule". Teachers saw such activities as allowing pupils to "do more investigative work" in which "if something doesn't work, then they can try something else". Approaches of this type were viewed as valuable both for introducing new ideas in an investigative way, and for reinforcing them as part of a revision programme:

> The [graphing software] I've used for a revision package for… students looking at different functions, where they have a graph drawn and they have to guess what the function is by drawing their own to make it superimposed over it. It's been quite a good revision package... It's also a good way of investigating it in the first place.

Indeed, it was suggested that pupils had an affinity with working at the computer in such a style:

> They are more prepared to have a stab at something and get it wrong, because not everyone can see it's wrong, and they'll keep trying until they can get it right./ I think it's their culture as well... They're less afraid than I am to try things. / Yes, I mean watching young people, often with software we're not absolutely happy with... they will find out things we haven't discovered because they're not afraid of pressing a button and seeing what happens. And I think they learn sometimes much faster through that than the structure that we're trying to give them.

There were similar comments on how, when programming Logo graphics, pupils "can see straight away when it's wrong... and they can correct themselves". Accordingly, occasional use of an "experimental" approach to Logo was seen as providing valuable opportunities for pupil exploration:

> If you just let them go freehand sometimes and you give them... just a basic worksheet with all the things that they can do on Logo, they come out telling you lots of stuff. They come out saying that if you do this repeat pattern you get this, and the more times you do repeat you get that... And I think that really, for them, it's more investigative and they find out. It's more of an experimental approach, rather than structuring them.

Enhancing the variety and appeal of classroom activity

Teachers pointed to ways in which use of ICT could bring variety to classroom activity, and enhance its appeal. There were many rather general references to activity involving ICT use as being "something different"; as "mak[ing] a change"; as adding "another dimension"; and – most frequently – as providing "variety". Allusions were made to the "novelty value" of work with ICT. There was talk of how pupils "like a change from the routine of the classroom situation" and "love to go to the ICT room". There were suggestions of pupils "enjoy[ing] seeing things done in a different way" and of "a different teaching and learning style".

Teachers' accounts hinted at a range of motivational components constituting the 'difference' associated with use of ICT, over and above bald 'change':

> Students are far happier playing on a computer and getting a computer to draw the graphs or solve different things rather than having to do it all by hand... It's just a different way, rather than being sat in the classroom, so I think they have benefited from that./... It's not having to write everything down, and they see it as a privilege to go in and use the computers, so already they're happy, they put more effort in just because it's a change.

Teachers emphasised the use of ICT tools to make tasks less "laborious", less "tedious and repetitious", so eliminating "the drudgery". Reciprocally, working with ICT could take on the character of "playing around". ICT was even dubbed "a motivating toy". Comments also elaborated how use of ICT could make activities more interesting, exciting and fun, including revision and reinforcement activities:

> It does get boring, lesson after lesson going through the [multiplication] tables in the same way, so I set up, on the spreadsheet, part of a multiplication grid and they had to complete it as quickly as possible.

Fostering pupil independence and peer support

In a less developed theme, teachers pointed to ways in which use of ICT could create opportunities for pupils to exercise greater independence and share their expertise. Comments about pupils' willingness to experiment with ICT have already been reported. Teachers noted how pupils had "shown themselves more self-sufficient than we are at using things like that", and how, given the opportunity, pupils could "go off and do amazing things". Such independence "gave them [pupils] some ownership over it and taught them how to do things for themselves, as opposed to just relying on having a teacher there". At the same time, teachers reported encouraging the wider sharing of pupil expertise:

> Often they can be quite effective at teaching the teacher and other students in the class about what they've found out on how to do it, which is good as well.

Overcoming pupil difficulties and building assurance

Teachers pointed to ways in which use of ICT helped to overcome particular difficulties which pupils might encounter in carrying out schoolwork, so removing the associated disincentives and building pupils' assurance. Computer mediation was seen as alleviating particular difficulties which many pupils -including those with special needs- experienced in writing, drawing and graphing by hand. Comments noted how using ICT "[did]n't involve… doing lots of [hand]writing, which is often something that the lower attainers… are unhappy doing", and overcame pupils' difficulties in drawing accurate graphs.

Teachers drew attention not just to the speed and ease with which ICT allowed mistakes to be corrected, but to their subsequent invisibility and impunity:

> If you're working in an exercise book, then I think some students don't respond well to situations where they make mistakes. Before you know where you are there's a scribble all over their books, but if you're working on a screen then it's just sort of click and then you're off again.

Further comments pointed to the directness and immediacy of computer processes as another factor helping to build confidence and persistence amongst pupils:

> Lots of them have writing difficulties. Lots of them have pen to paper motivational problems and this gets around all of those and means that they can get straight at it. They can tap, tap, tap and it's there. And they can get feedback immediately on how they're doing... The ones who are nervous know.

Teachers also drew attention to the satisfaction and pride which pupils derived from creating "work which is nicely presented":

> They can get printouts and copies in their books and have some nice neat work to look at. I think they can then start to feel more positive about themselves and their work, because often they can just get worse and worse with their untidiness, because they know they can't do it so they can't be bothered to try.

Focusing on overarching issues and accentuating important features

Teachers pointed to ways in which use of ICT could help to focus the attention of pupils on overarching issues, and to accentuate important features of situations under consideration. Comments reported how use of ICT could facilitate or automate subsidiary tasks – typically those involving routine data handling, calculating and graphing – freeing users to give their attention to more overarching matters:

> The key thing about… ICT applications [is] to take away the drudgery out of doing the calculations, so that you can start to access a higher learning point without the problems of making mistakes along the way clouding the issue.

Equally, teachers ensured that pupils appreciated the procedure being carried out by the computer:

> Normally I get them to work out the average first [by hand] so that they're seeing the process, and then they'll use the spreadsheet to do it, and then use the spreadsheet to print out some charts, so that they're working on the whole process that way.

Computer graphing helped pupils to "get over the stumbling block of actually drawing them in the first place [so that] they can actually see what they are and concentrate on that aspect", and to "draw twenty graphs in a lesson and actually see connections":

> It's just a case of typing in equations and... looking at gradients and intercepts. It makes the learning of that so much more efficient and so much more successful because they can see what's actually happening rather than spending time with pen and paper drawing graphs.

Teachers commented on how ICT could "be used quite effectively to offer clearer explanations, or visual ones at least", pointing not only to how "it would have taken forever to actually plot all the points and see what happens when you transform certain shapes", but to the way in which "it was done in a flash... and [pupils] accepted it because they'd seen it happening":

> You can… get them to draw various curves and show them what happens when you start altering the equation... In terms of actually looking at the curve shifting and so on, just… the immediacy of it, actually means that it hangs together better… It's just not better efficiency, but also it is actually sounder for the brain really, if it can see things more immediately.

Conclusion

In this study, our goal was to articulate a teacher perspective on successful ICT use. We think that the resulting thematic model may be of value in helping others – such as prospective teachers, teacher educators, and curriculum developers – to better understand the considerations shaping teachers' use of new tools and resources. Nevertheless, we are conscious that a casual reading of this model of *successful* ICT use could easily misinterpret it as an overly optimistic – and excessively deterministic – portrayal. Had space permitted, we would have been tempted to interleave more of the concerns and qualifications volunteered by our informants, so as to discourage such misreading. Essentially, the model identifies those states of pupil activity and forms of pupil progress which teachers valued and which they thought that use of ICT could help

them to achieve. We hope that this model will provide a stimulus to others – particularly teachers – to articulate additional and alternative ideas about successful ICT use which are similarly grounded in mainstream classroom experience.

References

Ruthven, K. and Hennessy, S. (2002). A practitioner model of the use of computer-based tools and resources to support mathematics teaching and learning. *Educational Studies in Mathematics* 49 (1) 47-88.

Ruthven, K., Hennessy, S., & Brindley, S. (submitted). Teacher representations of the successful use of computer-based tools and resources in teaching and learning secondary English, Mathematics and Science.