Being Interactive

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TI InterActive! is a recently developed computer application that combines the previously disparate environments and facilities of word processor, functions grapher, statistics package, CAS and web browser. This paper explores the potential of this package to enhance educational outcomes for secondary students within the contexts of teaching, learning and assessment. There is a particular focus on the opportunities the multi-representational, interactive and dynamic interface of this package offers teachers and students to develop richly connected understandings of mathematical ideas and concepts. This paper also identifies some questions this software application asks of designers of curriculum and assessment programs.

Introduction

Imagine a mathematics classroom where rather than being passive recipients of knowledge, students are the conductors of the orchestra of their own learning. Conductors who are able to draw on the many different parts of the orchestra to create a harmonious performance to be shared with other students and teachers alike.

To date, this has been difficult to achieve in mathematics classrooms because access to the necessary environment and tools have proved problematic in terms of user friendliness or cost — we have had conductors but it has been hard to get a full orchestra or baton. The recently developed computer application *InterActive!*, however, now offers students and teachers the opportunity to realise the potential of the computer in actualising the imagined dream of students as conductors.

What is *InterActive!*?

InterActive! is a mathematically active working environment within which there is direct access to dynamic mathematical, data collection and analysis, and wider communication functionality. The default working environment is that of a word processor with access to mathematical and communication tools available through clicking on an icon on the menu bar.

InterActive! has the mathematical functionality of the TI-83 plus graphics calculator (graphical, statistical, matrices) with the addition of an entry level Computer Algebra System. The software also provides access to a spreadsheet, and communication tools through a web browser. Data input can be from another computer (the WWW or through a LAN), from a TI-83 or TI-83 plus calculator or directly from data collection devices such as the TI CBL II[1].

Within the word processing environment students and teachers can create documents with embedded mathematical objects (graphs, calculations, tables and so on). For teachers, this means the ability to create and print good looking notes, worksheets, assignments, tests and so on without moving between software packages. Of far more interest in terms of the ways students might learn mathematics is the fact that the reader is able to work with the mathematical objects in the document. In an assignment, for example, the student might be asked to analyse and comment on some data or to investigate and report on the effects of various transformations on a graph. Both the data and the graph would be 'live' in a document that the student creates for themself.

Apart from responding in the context of an *InterActive!* file (as above), perhaps the most exciting prospect for *InterActive!* is that students will be able to write their own mathematics. This could be as reports of mathematical investigations, or scientific experiments that generate data. They will also be able to use the mathematical tools to solve problems posed by the teacher or that they set for themselves.

The individual components of *InterActive!* offer nothing that cannot be done in other ways, using other technologies. Its strength, and why it is seen to have such potential, is that these elements are brought together in a way that responds to and meets some of the key contemporary needs in the teaching and learning of mathematics. It is very much a case of 'the whole is very much better than the sum of its parts'.

The orchestra metaphor

Returning to the metaphor with which this paper began, *InterActive!* can be considered as a stage with the different instruments of an orchestra — each section of the orchestra is like one of the elements of the software's capabilities (graphical functionality as the strings; statistics as the woodwind etc.). The student is the conductor, with the computer's mouse as the baton.

In an orchestra it is the conductor's role to bring the disparate instruments together harmoniously. The conductor needs to know the capabilities of the instruments, and have a vision of what the end product should be like. So too the student bringing together the capabilities of the different components of *InterActive!* to create some mathematics and share it with others.

Of course the metaphor is limited. There is no score for *InterActive!*, and there is no orchestra equivalent of a student exploring a mathematical concept.

[1] *Interactive!* is a product of Texas Instruments which interfaces with other TI products.

Creating a mathematical performance

Consider the following problem as the premise for a student to engage in the process of creating a mathematical performance by students.

King of the Mountain

The great French rider Miguel Indurain won the Tour de France cycling race five times. This is a feat few other riders have been able to emulate in the history of the race. Indurain was renowned for his commitment to training, but to achieve these sorts of results an athlete must also have a genetic advantage over their opponents. One measure of an athlete's potential to do well at endurance events is their resting heart rate — Indurain's was reported to be astonishingly low. This left him a much greater margin for his heart rate to increase, when under physical stress, than many of his competitors.

Imagine a young Miguel Indurain was studying with you in this mathematics class. How would his heart rate compare with members of this class?

The stage

From within the word processing environment (the stage) a student could select the web browser to determine Indurain's heart rate, and then make use of other tools (the instruments) along the lines of what is described below.

The instruments

Web tools
A quick search by using the descriptor 'Miguel Indurain Heartbeat' could lead students to the web address (below) which records Indurain's heart rate as 28 beats per minute.

> Big Mig's Big Page
> http://members.tripod.com/~mcdowall/indurain.htm
> *Summary:*
> Big Mig's Big Page
> A page dedicated to Miguel Indurain
> Through his domination of the Tour de France in the first half of the 1990s, Indurain can lay claim to not only being the greatest cyclist of all time but one of the greatest athletes ever.

Data tools
Data on the student's classmates could then be collected on a graphics calculator and entered into lists within *InterActive!*. Alternatively, data could be collected on a graphics calculator and then transferred into *InterActive!* via a communications cable. As an example, a section of such a data set appears in Figure 1.

L1	L2
72	
68	
52	
48	
58	
68	
60	
76	
68	
72	
72	

Figure 1. Collected data entered into a list.

Graphics calculator tools

Once Indurain's heart rate has been added, the data can be analysed using the graphics calculator tools of *InterActive*!

We can see clearly from the box plot in Figure 2 that Indurain is an outlier within this distribution. The interesting question that remains is how much of an outlier. We can make use of our standard normal curve statistics to make a judgement on this.

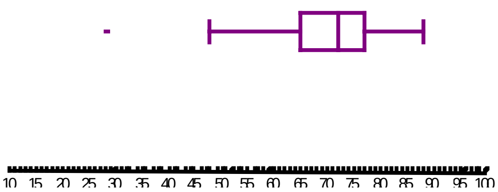

Figure 2. Boxplot analysis of the data.

The mean and standard deviation for the list can be calculated:

Xbar_

69.4444

sigmaX_

11.5721

We can again use *InterActive!* to find the z-score of this piece of data and then the proportion of the population that have a heart beat the same as this or less.

$$\frac{28 - \text{Xbar\_}}{\text{sigmaX\_}}$$

-3.58141

This is a long way from the mean! It is also most likely to be beyond the limits of a lot of standard normal tables. To overcome this problem we can use *InterActive!* or a graphing calculator and import the information into *InterActive!*. This method can be used to produce the result in Figure 3.

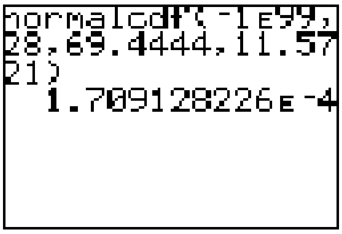

Figure 3.

The result indicates that Indurain has a heart rate that puts him in the company of only 0.00071% of this class!

How this would transfer to the wider world? Is he ‘one in a million’?

The performance

The composition produced by a student in many respects would resemble this paper as significant sections have been created using *InterActive!*. Their purpose may be to record their work, but there is great potential for them to describe a piece of mathematics to a wider audience than either themselves or their teacher.

Working with *InterActive!* would involve the student in writing a report of their investigations and work in a word processed document. Just as ‘objects’ (pictures, graphs etc) can be incorporated into documents prepared in the word processors we have become used to by clicking an icon and activating a software application that creates the object, mathematical objects and data can be created and incorporated at the click of a mouse.

The range of student performances is large and varied. Working on different problems would require selection of different *InterActive!* tools used in different ways, but in *InterActive!* they are available in one place – from the conductor’s podium via the click of a baton.

What are some of the advantages of *InterActive!*

It is always useful to identify a common frame of reference when discussing innovations and new possibilities in teaching and learning mathematics. For better or worse, the newly released Principles and Standards for School Mathematics from the National Council of Teachers of Mathematics in the USA (NCTM, 2000) has been chosen in preference to other possibilities. Among the reasons are that the new NCTM document:

- reflects and advances much that has been said over many years;
- draws on learning from recent research and analysis of practice; and
- is likely to be more internationally known about and understood than any other work in the area.

The NCTM Principles and Standards identifies three broad principles in relation to Technology and the teaching and learning of mathematics. These are that technology:

- enhances mathematics learning;
- supports effective teaching; and
- influences what mathematics is taught.

There is some evidence in the example above in relation to these principles, and it is not too difficult to identify other ways in which *InterActive!* brings life to these principles.

The ten Standards include five which are about ‘content’ (Number and operations, Algebra, Geometry, Measurement, Data analysis and probability). The elements of *InterActive!* clearly relate to work in the Algebra and Data analysis and probability areas more than the others, but the ingenuity of teachers is such that they will find uses in the other areas that are not obvious to the authors.

The capabilities of *InterActive!* in relation to the content areas are not, however, what is new when thinking about the package. It is the way these are able to be brought together to ‘do’ mathematics, dynamically and interactively, that is the innovation. Hence it is not surprising that the NCTM’s five ‘process’ Standards — those which relate to ‘doing’ mathematics — are the focus of initial thinking and development in relation to the package. The five NCTM ‘process’ Standards — Problem solving, Reasoning and proof, Communication, Connections and Representation — are all particularly relevant to the use of *InterActive!* in the school mathematics classroom.

Anticipating students’ work on the example provides a clear indication of the potential of *InterActive!* in relation to *communication*. Initially, they would need to use information-seeking skills to find data (relating to Indurain’s resting heart rate), and then to gather and organise their class data. They would be bringing together several different *representations* of the data (tabular, graphical and eventually numerical statements of summary statistics) in order to provide a clear description of their work and findings. The *connection* of their mathematics with their understanding about health and fitness, and to a ‘real world’ context would be apparent.

The example provides only limited insight into the capacity of *InterActive!* in relation to promoting Problem solving or Reasoning and proof. Readers would recognise, however, that appropriate tasks would readily lead to outcomes along these lines. The dynamic nature of the mathematical objects in *InterActive!* documents would, for example, allow students to explore ‘what if?’ question in order to practise and develop their *problem solving* skills. Through preparing an *InterActive!* document to report on work in which justification of answers is important, for example, students would need to use and develop skills with *reasoning and proof*.

Use of *InterActive!* in school mathematics classrooms is, as yet, in its very early stages. Hence there is no data in relation to any possibilities or problems with pedagogy. Some observations and predictions are possible, based on an appreciation of general findings about technology use and pedagogy in the context of an analysis of the features of *InterActive!*. As is the case with other implementations of technology in school mathematics, the use of *InterActive!* will diminish 'drudgery'. This will enable the student to focus more on the principles and concepts involved, and to work with and appreciate aspects of contexts of interest and relevance to them. *InterActive!* enables greater individualisation of learning, yet at the same time there is capacity for sharing of work inherent in both the communication orientation of the software in general, and the capacity to email files directly to other students in particular. Students will quickly be able to get good 'results' — documents that look professional. All this suggests that students' engagement with mathematics can improve and that their dispositions towards doing mathematics will be enhanced, with likely positive impact on performance.

These comments only begin to identify the advantages that *InterActive!* can provide teachers and students. There is real potential for the work of teachers and their students to push the edges well beyond these fairly tentative initial suggestions. It will be important that their efforts are recognised and shared among colleagues over the coming months and years.

What are the challenges for curriculum development?

On the one hand, the fact that *InterActive!* contains tools that are otherwise already available means that its use will mesh directly into current curricula which exploit the use of technology. It is widely and immediately applicable in the framework of such curricula.

The challenges for curriculum development and teaching practices come from the innovative aspects of *InterActive!*, in particular the integration of tools, access to tools and the ease with which dynamic, interactive mathematical documents can be produced by teachers and students. It is not unreasonable to suggest that the result may be some very different learning experiences for students; opportunities for students to work in different ways; examples of 'best practice' assessment.

Conclusion

InterActive! is an environment with great potential. Over the short and medium term teachers will need to be supported to begin to realise this potential through professional development and teaching resource support. Even over these timeframes — and certainly in a two or three years — the journeys of those teachers and others who work with *InterActive!* will almost certainly take them trough much new territory in school mathematics. These will be exciting and rewarding journeys that look like being well worth the effort!