Teachers researching their own practice: Evidencing student learning using TI-Nspire

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It is generally accepted that the introduction of interactive technologies into secondary mathematics classrooms presents new challenges to teachers and students both mathematically and pedagogically. This paper reports a case study approach as a teacher began to use the TI-Nspire handheld and software in secondary mathematics classrooms with pupils aged 11-16 years as part of a pilot project. The focus will be on the methodology employed by the researcher in eliciting the teacher's perceptions of the ways in which the technology was impacting on teaching approaches and learning outcomes, with an emphasis on the affordance of the mathematical process skills.

Keywords: mathematics; classrooms; teachers; handheld technology.

Handheld technology designed to support mathematical learning has developed substantially from the previous generations of graphic calculators. New platforms such as TI-Nspire (Texas Instruments 2007) allow users to exploit the use of linked multiple representations to explore, solve and present illustrated solutions to a wide range of mathematical and scientific problems in a combined handheld and software option. The research reported in this paper comprises an aspect of the English TI-Nspire Evaluation Project (2007-8) which is one of a wider series of studies investigating the integration of the technology in Australia, France, Italy, Germany and the Netherlands (Aldon et al. 2008; Arzarello & Robutti 2008; Clark-Wilson 2008).

The English study was designed to qualitatively evaluate the impact of using TI-Nspire in secondary school mathematics classrooms, building cumulatively on existing understanding of teaching secondary mathematics with technology, by concentrating on pedagogies which exploit the new functionality offered by TI-Nspire as an ICT tool for mathematics, with a view to adding to the discourse on how teachers make sense of multiple representation functionality for teaching.

The project timescale was from July 2007 to June 2008 and it involved pairs of teachers from seven English state-funded schools, which ranged in attainment from 25% - 75% of students achieving a Level 2 qualification, including mathematics (2007 validated data). The teachers, who also ranged in both their teaching experience (1 to 37 years) and their (self-confessed) confidence and competence in the use of technology in the classroom, participated in over 50 hours of face to face support through both residential conferences and school based support (in and away from their classrooms), as well as 'phone and email contact. The project has an online community, established to support the sharing of lesson resources as they develop, and the project team included experienced practitioners, authors and activity designers within this form of technology. As TI-Nspire was still in development throughout the project's timescale, the teachers and developers were both 'growing up' with the tool, resulting in a collaborative community in which each group listened to each other's perspective regarding the use of TI-Nspire and the evolving design of classroom activities and approaches. This research sought to explore how TI-Nspire might support students to learn mathematics with understanding and to elicit the successful elements of a professional development experience for teachers learning to use TI-Nspire technology in their classrooms. The project is framed within a period of curriculum reform in England, with a new National Curriculum emphasising the process skills involved in mathematical learning. Consequently, the teachers were becoming more aware of how their classroom assessment of students' mathematical outcomes could be evaluated by focusing on how the technology might support students to: represent mathematics; analyse mathematics; use appropriate mathematical procedures; interpret and evaluate mathematics; and communicate and reflect upon mathematics. (Department for Children Schools and Families 2007).

The project data comprised predominantly the evaluated lessons, collated by the teachers with support from their mentors, which included some or all of:

- lesson plans and supporting files (i.e. Smart NoteBook files, Moodle pages);
- TI-Nspire files (teacher and student versions);
- teachers' ongoing reflections and informal observations
- teachers' lesson evaluations;
- students' work (.TI-Nspire files, screenshots and written work);
- mentors' lesson evaluations;
- students' lesson evaluations.

The teachers' lesson evaluations proved to be the most effective way of eliciting the specific detail of the lessons, and the questions that formed the structure for these descriptions are given in Appendix A. These questions were adapted from a framework developed for the West Sussex Numeracy Project as reported by Ahmed and Williams (1997). This paper will comment on the early data analysis in relation to the first of the research questions and examine how one teacher described her students' outcomes of a lesson, reported to the project with the support of the methodological tools designed by the researcher.

Using TI-Nspire to explore gradients of perpendicular lines.

Eleanor, a teacher with 21 years experience and with a keen interest in using a range of technology in her teaching chose to use the handhelds with a group of high achieving 14-15 year old girls to consolidate work they had previously carried out relating to the gradient and intercept properties of linear equations. She stated her aims for the lesson to be:

> For any function written in the form y= mx +c that the perpendicular function is written in the form y=-1/m x + c. (New task for Module 9).
>
> To reinforce understanding of parallel lines and gradients (Skill gained within Module 8). [CEL5]

These lesson aims relate closely to the students' examination curriculum and reflect the current teaching climate in England, in that teachers are encouraged to have clear aims for their teaching, an established practice in her particular school. It was common amongst the teachers in the project to report lesson aims that were content, rather that process driven.

Eleanor adapted her lesson from one that had previously been shared at one of the project meetings by another teacher. However, Eleanor later acknowledged that she had forgotten the exact approach the other teacher had reported, and so devised her own strategy, which she later reflected upon in her evaluation.

Using the Graphs and geometry application within TI-Nspire, she asked the students to graph a familiar linear function, with most choosing $y = x$ or $y = 2x$ to begin with. Eleanor then asked the students to use the line construction tool to add a (freely drawn) line to their screen, which appeared to be perpendicular to the function. (This appears as a line segment in figures 1 and 2 below). Eleanor then showed the students how to measure the angle between the linear function and to drag the position of the line segment, such that the measured angle was 90°. Finally, the students were asked to generate further linear functions that appeared to be parallel to their empirical line.

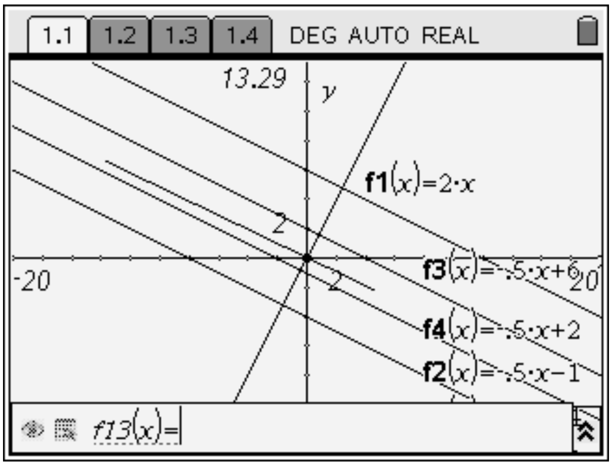

Figure 1 Screenshot: student A

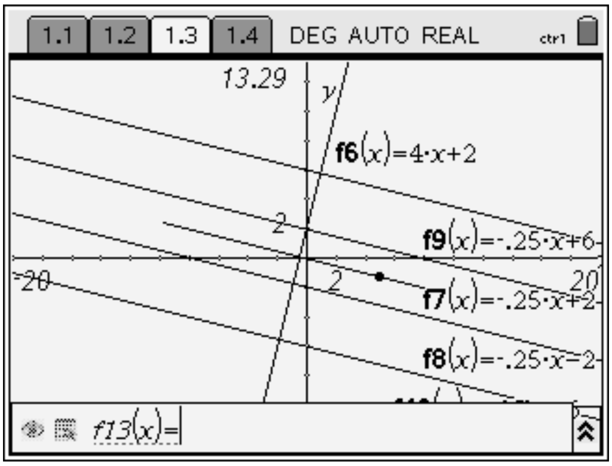

Figure 2 Screenshot: student B

In her written evaluation, Eleanor reported that this approach encouraged the students to seek many answers and she supported this with the screenshots shown in figures 1 and 2. The students had also been encouraged to record their own findings using the *Notes* application in TI-Nspire, with an emphasis on trying to generalise mathematically. Eleanor selected the screenshot shown in Figure 3 as an example of one student's response to this part of the task.

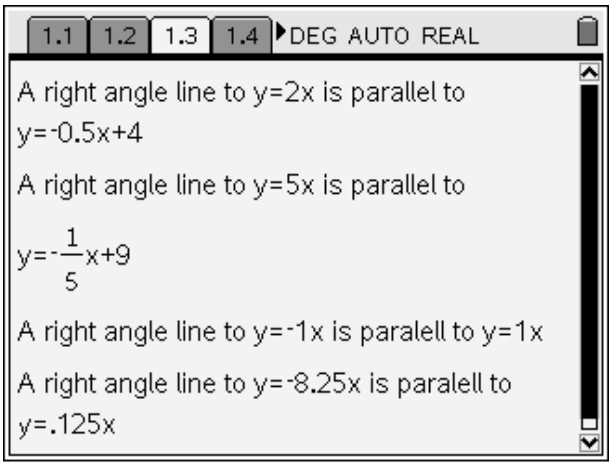

Figure 3 Screenshot: student C

In responding to the evaluation question, "Did the use of TI-nspire enhance the mathematical understanding of the students?" Eleanor responded,

> Definitely. The time saved in not having to draw out any graphs is the main factor when using this technology. Trial and improving different functions enables girls to experiment and, by establishing their own rules/findings, they have a better understanding of what the conventions are. [CEL5]

In a post-lesson discussion, Eleanor considered how she would develop the activity in the future by using the measure-slope functionality tool to enable learners to build a table of values within the *Spreadsheet* application. She wrote that she would develop the activity to include the following foci:

> To reinforce looking for connections between perpendicular gradients as written for the value of m. To encourage more formal methods of recording results. To introduce a spreadsheet page to establish that the product of perpendicular gradients is -1. Slope can be measured. Ensuring all hand-held are in degree mode and all with a float of 3. [CEL5]

Eleanor also remembered the approach taken by the original teacher, which was to "guess" the equation of a perpendicular line, measure the angle between the two lines, then use built-in functionality to drag the new function until the angle measured 90°, and observe the new function.

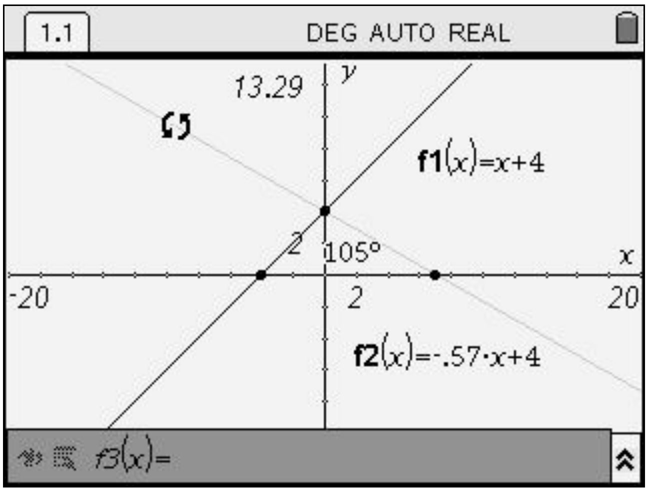

Figure 4 Using the function drag mode to explore perpendicular functions

A consideration for any educational research, for which the primary data source is teachers' accounts of the impact the technology has had on the students' classroom experiences, relates to the objectivity, reliability and validity of the research. This point is referred to as a problem for mathematics education research by Goulding and Kyriacou in their EPPI review of the use of ICT in developing pupils' understanding of algebra, where many of the studies they reviewed focussed on individual or pairs of students, whilst omitting to consider the typicality of the chosen students' responses. (Goulding & Kyriacou 2008) In the example described above, Eleanor selected the evidence that she felt justified her overall evaluation, that the use of the technology had enhanced the students' learning experiences. However, to gain a wider perspective of the experiences of the whole class, it was necessary to set the positive evidence alongside the teacher's response to the series of questions:

- Approximately how many of the students could develop strategies to fully pursue the activity with little or no guidance from you?
- What, if any, guidance did you have to give to the other students? (*Please indicate how many students approximately needed additional guidance?)*
- Give examples of the sort of interventions you made.

This series of questions often revealed the less positive aspects of the lesson, and it was possible to categorise these with respect to the mathematical concepts being explored, the difficulties relating to the instrumentation of the technology (by teachers and students) and those relating to the complexities of the task itself. In Eleanor's case, she reported:

> They were very adept at using the technology and about 80% recalled that the gradient must be negative. This was a very good starting point with no additional guidance from me. (A few girls did, however, need to just check this fact with me!)
>
> They had a handheld each and very naturally helped each other out, especially when technical questions were asked. About 15% needed some guidance when faced with such an open-ended task. Suggestions were made at which functions could be tried out. About 5% were technical issues in finding menus and using the grab-hand. [CEL5]

From Eleanor's responses, it is possible to gain a sense that the majority of her students were able to use the technology to engage with the task and that they were mostly able to provide mutual support to overcome both technical and mathematical difficulties that arose. It also reveals evidence of the ethos of the classroom, where students' responses appear to be valued and the meaning for the tool has been created by the learners themselves in the sense of Hiebert et al (1997).

Understanding teachers' views of how technology could be used most effectively within mathematics education is an essential part of knowing when and how teachers choose to use or reject certain forms of technology within their classroom practices. It is proposed that related studies should develop robust methodological instruments that enable teachers to consider widely the impact of technological tools by probing all students' responses to tasks. Within the context of research into TI-Nspire, this will be made possible through the wireless networking technology that is being developed, which will enable real-time observation (and recording) of students' task responses in addition to the easy transfer of the students' files.

Appendix A

Teachers' lesson evaluation questionnaire

What did you want the students to learn?
What activity did you choose (or develop)?
And what mathematical learning took place?
How did you introduce the activity?
What were students' initial reactions/questions?
Approximately how many of the students could develop strategies to fully pursue the activity with little or no guidance from you?
What, if any, guidance did you have to give to the other students? (*Please indicate how many students approximately needed additional guidance?)*
Give examples of the sort of interventions you made
How did the activity enable students to take more responsibility for their mathematical learning?
Give a brief summary of the students' work/conclusions
How did the idea influence further work?

What aspect(s) of the idea would you use again?
What changes would you make?
Any other observations…? pupils' comments…? other teachers' comments…?
In your view, did the use of TI-Nspire enhance the mathematical understanding of the students?
If yes, what evidence would you use to support this?

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