

## **Connecting mathematics in a connected classroom: Teachers emergent practices within a collaborative learning environment**

Alison Clark-Wilson

*The Mathematics Centre, University of Chichester*

During 2008-9 seven secondary mathematics teachers from England, Scotland, Netherlands and Sweden began to use a wireless classroom network to link their students' handheld ICT devices. This paper focuses on the teachers' reported uses of the Screen Capture feature, which were coded to reveal patterns in the emerging classroom practices. Analysis of the data revealed: increased opportunities for purposeful classroom discourse; improved formative assessment practices; and highlighted the need for teachers to choose rich examples on which to build the mathematical tasks.

### **Mathematics, ICT, Teacher development,**

#### **The Research Context**

Following on from the English TI-Nspire™ handheld pilot evaluation in 2007-8 (reported in Clark-Wilson 2008) Texas Instruments funded a second project which introduced the TI-Nspire™ Navigator™ wireless classroom network system to the existing handheld classroom environment. Two of the teachers involved in the English project joined teachers from Sweden, Netherlands and Scotland in beginning to develop viable classroom approaches and evaluate their associated outcomes. Of particular interest were the ways in which the teachers perceived that the introduction of the network changed their classroom environment and the nature of the tasks that they could set. The focus of the pilot was limited to the following TI-Nspire™ Navigator™ functionalities: File management, Screen Capture; Quick Poll; Live Presenter; Class Analysis. This paper will report specifically on how the teachers used the Screen Capture feature. Whilst the cultural aspects of mathematics teaching within the different country settings is of great interest, this is not addressed within this paper due to the limitations of space.

#### **Theoretical framework**

At the heart of this study was an exploration of teachers' classroom practices, and in particular those which enhanced and promoted opportunities for student (and teacher) learning, resonating strongly with research into formative assessment practices. The interpretation of formative assessment adopted by the researcher throughout this study (and shared with the teachers) is best articulated by Black and William who write:

[Assessment] practice in a classroom is formative to the extent that evidence about student achievement is elicited, interpreted, and used by teachers, learners, or their peers, to make decisions about the next steps in instruction that are likely to be better, or better founded, than the decisions they would have taken in the absence of the evidence that was elicited. (Black and Wiliam 2009, p. 9)

Consequently, the research focused on providing opportunities for teachers to describe and evaluate their practices, and in particular on the way in which the information gained through the use of the technology impacted upon their decisions and actions in the classroom. A number of previous research studies into the use of TI-Navigator™ with TI-84 graphing calculators in the United States, Canada and France had concluded that the opportunities for formative assessment had been enhanced (Dougherty 2005; Hivon, Pean, and Trouche 2008; Sinclair 2008). For example, a pilot study on one classroom in Hawaii concluded,

The use of TI-Navigator technology supports the development of a collaborative classroom environment by enhancing student interactions, focusing students' attention on multiple responses, and providing opportunities for students to peer- and self- assess student work. The ability to display a full class set of data or task responses supports a problem-solving approach to developing skills and concepts. (Dougherty 2005, p.28)

In addition, the notion of a 'collaborative classroom' was a reported outcome of a French study (Hivon, Pean, and Trouche 2008) which also suggested that the TI-Navigator™ had changed the nature of the mathematics classroom environment by:

offering an opportunity to change the nature of classroom mathematics tasks;  
offering new opportunities for both cooperative and collaborative group learning;  
and increasing the complexity of the teacher's role with respect to 'orchestrating' the lesson. (Hivon, Pean, and Trouche 2008)

The notion of 'orchestration' expands upon the complex nature of the teacher's role in 'conducting' a lesson using networked handheld technology, with a number of researchers offering emergent theories on this theme (Trouche 2004; Drijvers and Trouche 2008; Roschelle and Pea 2002).

Finally the nature of the task design with technology was an important consideration with the study, and in particular the choice of mathematics examples (which constituted the task) and the resulting classroom discourse (Ainley, Pratt, and Hansen 2006; Goldenberg and Mason 2008). The classroom network offered a new opportunity for the design of tasks, although this paper is not reporting specifically on this outcome (see Clark-Wilson 2009 for a fuller account).

## **The Research Approach**

The research sought to collate evidence from the teachers about the aspects of the classroom use of TI-Nspire™ Navigator™ that promoted desirable classroom pedagogies and the nature of the rich mathematical starting points that might lead to enhanced student engagement and achievement in mathematics. A set of subsidiary questions were developed for each of the system's functionalities and, for the Screen Capture feature, these were:

- What was the nature of the 'rich' mathematical starting points for which Screen Capture stimulated pupils (and teachers) to learn mathematics?
- How could Screen Capture be used to maximise the opportunities for students' peer communication with (and independent from) the teacher;
- What classroom strategies did the teachers devise to use data from Screen Capture to support them in all aspects of formative assessment?

The teachers met for an initial one day meeting at which they shared some of their early classroom approaches and the project community begun to be established. At this meeting they were introduced to some of the technical aspects of the system and the research protocols through which they would report their classroom experiences. The group also spent time, with expert support, developing some starting points for mathematical activities which used the collaborative sharing of students' handheld screens as a fundamental aspect of the task design. I stimulated this discussion by offering a number of simple activity ideas which exemplified this approach. For example, by asking students to all enter a function which they thought would pass through a particular coordinate point on a common set of axes.

Each teacher was asked to complete a detailed lesson evaluation (Less-eval) for at least 3 selected lesson taught during the Spring and Summer terms 2009 and submit them with any relevant accompanying evidence which typically included students' work, Screen Capture images, students TI-Nspire™ handheld files, lesson plans and the teacher's own reflective comments. The nature of this lesson evaluation process was reported in an earlier BSRLM paper (Clark-Wilson 2008). In brief it provided a structure for teachers to record information about the class, the mathematics to be taught and to tell the story of the lesson and its activity, whilst encouraging teachers to reflect upon the multiple and various outcomes. This data was analysed using a constant comparison approach, influenced by grounded theory (Glaser and Strauss 1967) through which a number of emergent practices became evident. This data analysis was supported by the use of Nvivo7 software (QSR International 2008) which facilitated the data analysis process and the systematic coding and grouping across the range of data types.

In addition, each teacher was observed at least once using TI-Nspire™ Navigator™ with a class and the teachers also participated in a semi-structured interview (Int) directly after each lesson which probed specific choices and actions they had taken during the lesson.

### **So what is the Screen Capture feature within TI-Nspire™ Navigator™?**

Normally, when working with a class who are using a handheld device such as a scientific calculator, graphical calculator or TI-Nspire™ handheld, the individual screens are private to the user and teachers would observe the students' mathematical activity by moving around the classroom or, with some devices, inviting students to connect their device to a whole class display.

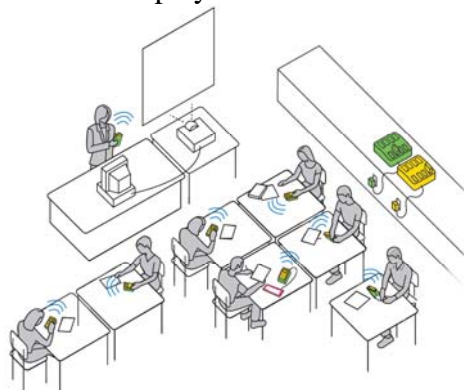


Figure 1 The TI-Nspire™ Navigator™ classroom network

The TI-Nspire™ Navigator™ classroom network requires students to log into the ‘class’ which enables the teacher to use a range of features, one of which is to choose to display all of the students’ handled screen simultaneously. Using one of the reported lesson examples, Figure 2 shows an example of this view.

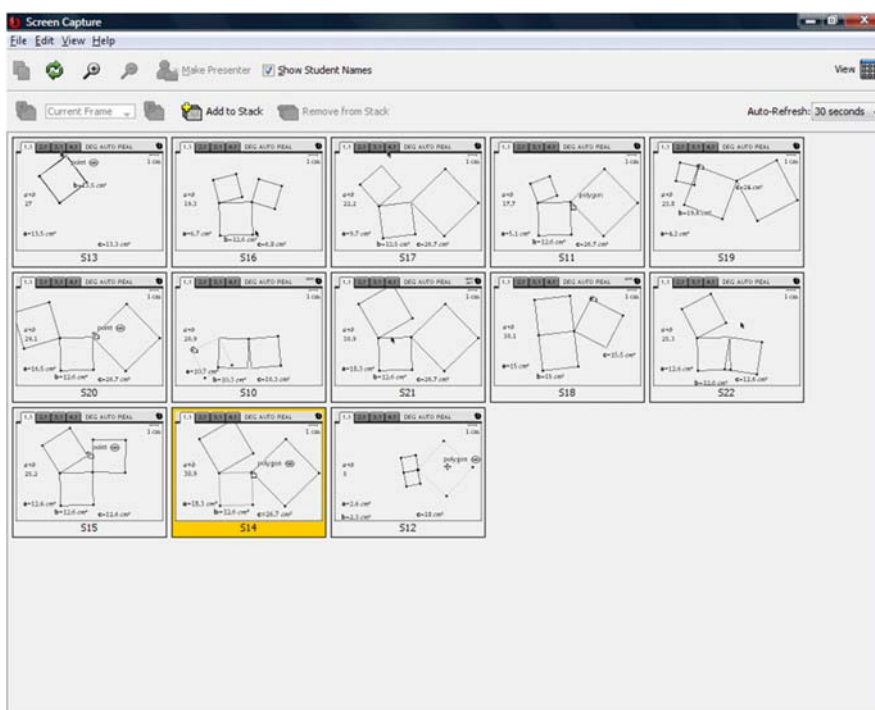


Figure 2 A Screen capture view of the students responses to a mathematical task

When using Screen capture, each teacher chose whether to display this privately on their own computer or display it to the class using a data projector. This paper will focus on examples where the teachers chose to make it a central feature of their task design and associated mathematics pedagogy.

## Research Results

The Screen capture was used in 23 of the 25 lessons that the teachers reported to the study and teachers were unanimously positive about their experiences. The data analysis led to the following categories of use: monitoring students activity during the lesson; supporting teachers to know when to intervene; promoting and initiating whole class discourse; promoting and supporting peer- and self- assessment; privileging mathematical generalisation; increasing sample sizes (within statistical work); and enabling mathematical sorting.

What follows is a description of each of these usage categories with supported by the teachers’ evaluations based on their classroom experiences.

### *Monitoring student activity during lessons*

All of the teachers reported that the use of Screen Capture had enabled them to monitor students’ activities whilst they were working with TI-Nspire™ during lessons. The rationale for this monitoring varied, with some teachers using this functionality in a passive way to check ‘that every student is working – doing what they were supposed to do’ [Int] and ‘to ensure that everyone got to the first page

okay' [Int]. There were a small number of lessons where the teachers used Screen Capture privately on their own computer (e.g. whilst the students were completing a test). However, in the vast majority of lessons the Screen Capture display was on public view in the classroom. This prompted a much more active use about which the teachers were highly enthusiastic, namely the insight that Screen Capture gave into how their students were engaging with the tasks they had been set.

Some teachers said that they were monitoring the students' work for pace, both to observe the students' natural work rates and to impose an expected work rate. One teacher said it was to 'spur on the learning' [Less-eval] and another 'to selectively sample the class work and drive the activity forwards by challenging them with new situations they had constructed' [Less-eval]. One of the notable comments made by several teachers related to an appreciation that the pace at which their students worked was much more widely distributed than they had previously appreciated.

Several teachers commented specifically on the value of Screen Capture as a window into their students' progress through the lesson. In one lesson evaluation, the teacher commented,

Screen Capture gave me instant feedback throughout regarding student progress. As a teacher you develop a sense of how a lesson is progressing based on the level of noise, the snippets of conversation that you hear, etc. However, in this lesson I was able to 'see' what students were doing. This adds to the other sensitivities that I have so that I am able to make better judgments. [Less-eval]

Other teachers reported that they were monitoring specifically for the purpose of identifying exemplar solutions and common (or particular) mistakes, which in some cases led to an individual or whole class intervention by the teacher.

### ***Supporting teacher interventions***

In all cases, the reported use of Screen Capture led to some action or intervention on the part of the teacher. These ranged between interventions involving individual students (or groups of students) to the initiation of focusing activities involving the whole class.

By far the majority of teacher interventions related to those of a pedagogical and mathematical nature concerning the task itself. In many cases the teachers used the initial Screen Capture view to identify particular students (or their screens) as the focus for the whole class discourse. In some cases this led to the identification of one student to become Live Presenter<sup>1</sup>, and in other cases to highlight particularly interesting solutions or responses.

Some teacher interventions following the use of Screen Capture arose from their observation of issues the students were experiencing with their use of the TI-Nspire™ files. For example 'I adjusted my advice for how to keep the triangles on the screen by reducing all of the lengths to smaller numbers' [Less-eval] and 'I had to use Screen Capture to see why they did not find any connection... I could see they had dots everywhere so I had to resend the file.' [Less-eval]. This also supported the teachers to appreciate issues within the design of the TI-Nspire™ file by 'learning from how the tns file was interacted with and what things could too easily be 'broken' with it' [Less-Eval].

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<sup>1</sup> The Live Presenter feature enabled the selected handheld display (and key presses) to be wirelessly displayed to the whole class through the data projector.

There was evidence in their lesson evaluations to suggest that, as the project progressed, the teachers were becoming more aware of knowing when to intervene and who to intervene with and also used the information from Screen Capture to inform them as to when the students were ready for them to progress with the lesson content. This took the form of suggestions as to how they might manage different pedagogic situations differently or how they would redesign tasks to build in opportunities to solicit students' responses.

### ***Promoting whole class discourse***

A common reason cited by the teachers for the use of Screen Capture was with the intention that it would promote discussion and communication in the classroom. The outcomes of this were positively reported by one teacher, who said 'Seeing each others' work gave a wider discussion through the class than what normally happens between students seated next to each other' [Less-Eval]. The nature of this discourse varied. In the observed lessons it tended to be a more teacher dominated discourse of instruction and explanation, but there was evidence in two classrooms of the teacher using the Screen Capture view as a prompt for the students to discuss amongst themselves prior to feeding back their thoughts to the whole class.

### ***Promoting and supporting peer assessment***

The diversity of student outcomes that Screen Capture made public resulted in several examples from the classrooms in relation to the opportunities for both peer- and self-assessment. The following quotes provide rich evidence:

The students could 'learn from each other and see their mistakes'. [Less-eval]

Some students also watched to get ideas and support. [Less-eval]

The sharing of thoughts at the half-way stage led in several cases to students checking some of the declarations that had been made by their peers. [Less-eval]

It is really fantastic to see how much the students learn by just looking at each other on Screen Capture. [Less-eval]

Other teachers were more specific about how the use of Screen Capture had supported the students to communicate their mathematical ideas and associated thinking, again leading to improved responses as a result of viewing the responses of their peers.

### ***Privileging mathematical generalisation***

An initial aim for this pilot study was to actively encourage the teachers to consider the mathematical topics for which sharing a variety of students' responses would have a clear mathematical purpose. The teachers responded to this challenge very positively and some rich mathematical examples were generated. The underlying principle for all of these tasks was to create a shared learning space through which all students' contributions contributed to the 'big picture' and, with careful teacher questioning and prompting, the students were able to make sound mathematical generalisations. The sort of mathematical aims that the teachers proposed were for students to explore the function family  $y=ax$  'to see how the value of  $a$  will have a different impact on the graphs' [Less-eval] and 'that there are infinite number of straight lines through a certain point' [Less-eval].

The major feature of these lessons was the emphasis on similarity and difference (two fundamental mathematical concepts) and the teachers made particular

comments in relation to both of these with respect to how Screen Capture facilitated a new approach to the mathematics:

After some exploration there were 16 screens with all different situations. [Less-eval]

I wanted the students to 'see the different lines that they had all drawn through the same point' [Less-eval]

I wanted Screen Capture to 'show a variety of results... the idea being that we could all see that right angled triangles gave the right solution'. [Less-eval]

One teacher justified this approach by saying 'I needed every student to see many different screens to come to the generalisation. If they only see their own screen they lack a global view.' [Less-eval]. In these examples Screen Capture enabled the use of the shared learning space to focus the students on the common part of the task. This sense of a collaborative learning environment was captured by another teacher who wrote, 'We are in this together – the knowledge is shared – not 25 individuals' [Less-eval]. Several of the teachers commented that they would be keen to further develop the mathematical TI-Nspire™ activities which would exploit this use of Screen Capture.

### ***Increasing sample sizes (within statistical work)***

An interesting mathematical use of Screen Capture emerged from three lessons in which the Screen Capture view was used with purpose within lessons involving work in statistics. In these three cases the teachers explicitly commented on how the mathematical relevance of sample size could be promoted to the class by seeing everybody's data. In one case this was 'to show that when students showed the same RandSeed number, all screens in the next Screen Capture showed the same random number' and in another to 'take a snapshot of how many students were getting a better estimate – to tally up-front'. This suggests a potential use of Screen Capture which might be worth developing further within the design of TI-Nspire™ activities for use with TI-Nspire™ Navigator™.

### ***Enabling mathematical sorting***

One lesson attempted to use the students' Screen Capture displays as objects for sorting into those which did and did not have a particular mathematical feature. However, the current functionality of TI-Nspire™ meant that, as the screens automatically 'snap to grid' it was not so easy to make obvious to the students where the boundaries of the groups lay as the screens were continuously reordered in fixed grid layout. This also highlighted the facility to colour code the individual screens as an alternative way to draw attention to particular mathematical features as potential future functionality within Screen Capture view.

## **Conclusions**

The analysis of the emergent practices that the teachers developed revealed that TI-Nspire™ Navigator™ was used to:

- develop new and support existing formative assessment practices;
- enable the development of innovative mathematics tasks;

- support teachers' lesson planning to include desired pedagogical approaches, lesson organisation and classroom management strategies;
- support the use of the TI-Nspire™ handhelds for individual and whole-class work.

In conclusion the research reported in this paper has provided an insight into the emergent practices of teachers' uses of one of the features of the TI-Nspire™ Navigator™ system. The findings suggest that the ICT offers opportunities for teachers to both rethink the design of ICT-based mathematical tasks for collaborative learning approaches and their underlying pedagogical approaches.

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