GETTING AN INSIGHT INTO HOW STUDENTS USE THEIR GRAPHICAL CALCULATORS

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I report on a data collection tool that I used within my doctoral studies. My study investigates the depth and type of learning that takes place when a student uses a graphical calculator within an AS Level Mathematics course. I collected various types of data during the project: interviews; observations; student journals; key-stroke data from graphical calculators and combinations of all four. The key-stroke data was collected using a piece of software called Key Recorder that runs in the background of a graphical calculator recording all the user's key strokes. It is then possible to playback the data file to see what the user saw and determine how they used their graphical calculator. I plan to outline some features of the Key Recorder followed by some initial observations made during analysis of the data I have collected.

BACKGROUND

There is a great deal written about how technology within the mathematics classroom will enable students to improve their learning and understanding (Ruthven, 1990; Hennessy, 1998; Kendal & Stacey, 2001; Heid, 2002; Hoyles, 2003) but there is still some lack of understanding as to which students benefit and why. Surely one element is a sense of ownership of the tool. Wertsch (1998) calls this appropriation and describes it as when the artefact or tool is adopted for the individual's own intention and also that it involves some level of mastery. (It is this use of 'appropriate' that I use here.) This is a major focus of my doctoral study – how and where does the student use their graphical calculator (GC)? If the student can appropriate the GC then it can become an instrument to help with problem solving and although the student will need to consider how to use the GC they will hopefully focus on the mathematics problem. Some French studies show a strong focus on the importance of developing a relationship with a piece of technology (Guin & Trouche, 1999; Artigue, 2002). Guin and Trouche (1999) conducted a study where a group of students were given a computer algebra system (CAS) calculator to use at home and school. They found that over time a relationship developed between the student and the tool – the student appropriated the tool. Trouche (2005) writes that students learn to use their GC outside the classroom and appropriating the GC begins with individual exploration, followed by a social interaction.

Weigand and Weller (2001) investigated student working styles while using computer-based CAS for solving mathematical problems. They used the software which recorded the user input and saved the information onto the computer's hard disk. For my project I wanted to collect data from whenever and wherever students were using their GC so I

collected data via some software located in each student's GC. Collecting data in this way meant that the students are rarely aware that they are being monitored and also the data is an exact record of the students' activities with the GC. Below I briefly describe the software, its functioning and some advantages and disadvantages of using it as a data collection tool.

KEY RECORDER

Key Recorder is a piece of software that has been designed to run on a TI-83+ or similar GC – an extended memory capacity is essential. The program runs in the background recording all the key strokes and it is then possible to playback the data file and observe how the students used their GCs. When Key Recorder is collecting data the GC operates as per normal and at the same speed, so there is little indication to the student that data is being collected.

The software program can be loaded onto a GC from a PC with the use of TI-Connect[1], alternatively it can be transferred from GC to GC. Unfortunately it is not possible to access the program to either view or edit it. Data files from Key Recorder can be transferred from one GC to another, although each GC can only store one at a time. Alternatively the data files can be transferred to a PC and given a more meaningful name other than AKyRecd.8xv which is the default name assigned to each data file. The only way of viewing the contents of a file is to transfer the file from a computer onto a GC as there are no other programs able to run or edit files of this type.

The Key Recorder data file can be played back and viewed in 2 forms: View Data and Replay Data. View Data will show all the key strokes made by the user and Replay Data runs through the data file making it possible to see what the student saw on the GC screen.

Advantages

Key Recorder provides an exact account of how the GC is being used by storing a list of all the key strokes made by a user. The data can be used in many ways: to identify how a student's use of the GC changes over a period of time; if there any repeated errors; how a student attempts a mathematics problem. It also provides the opportunity to see if they are using it in the way they were taught. It can show if the student has found alternative methods to those being taught by the teacher or are teaching themselves to use the GC to investigate areas of mathematics that are not on their syllabus. I followed six students during their one year AS Mathematics course and was able to find evidence within all these areas.

Key Recorder also indicates how a student uses the GC outside of a mathematics classroom. Students within my project were asked to enter an alpha code into their GC before using it. This was in an attempt to identify their work at different times and in different situations: work in the mathematics classroom; within other AS classes; at home or outside formal classes. Although this was not totally successful throughout the year it did provide some indication of how the students used their GC outside of the mathematics classroom.

Disadvantages

Replay Data shows the GC display as seen by the student but the entire data file will be replayed all in one go and the playback is extremely fast which does not permit easy analysis of the data. It is not possible to pause the playback but it is possible to halt it - by pressing the ON key. If a student runs a program while the Key Recorder is collecting data the playback will halt at this point and the program will begin to run. It is possible to see the keystrokes that have been made after this point but the playback must be changed to View Data. Playback will also stop when the maximum file size is reached. I often over-estimated the size of the data file needed knowing there would be sufficient space to store the data.

Using View Data it is only possible to see 8 key strokes at a time – one per line. The data files can be scrolled through one line at a time but with large files (up to 9000 keystrokes) this can be laborious. It is not possible either to skip from one section of the file to another which means if it is the end of the file that is under analysis the file must be scrolled through one line at a time.

During periods when data collection exceeded one lesson, it is likely that the student will have turned the GC off or it will have 'timed out'. Neither of these situations can be identified by examining the keystrokes as Key Recorder does not record when ON or OFF key has been pressed. While this is understandable - during playback the Key Recorder would turn the GC off and therefore not be able to continue playback - it would ease analysis if there was an indication whenever the student switched off the GC or it timed out.

If a student allows the GC to 'time out' while they are in a screen other than the HOME screen and then switches it back on, the GC will continue from where it was before it timed out. However, if a student switches the GC off and then later switches it on the GC will automatically return to the HOME screen. Key Recorder will not record that the GC has been switched off but will continue playback in the mode that the student had been previously working. While this is not a problem for the student, this can cause significant confusion with playback and analysis of the data and it can produce errors during playback that the student will not have experienced. For example: a student enters an equation to be graphed through Y= and then turns the GC off. When they return to the GC and turn it on they will have the Home screen to work with. During playback the display will not register that the GC was turned off/on but it will continue all playback within the Y= screen.

It is also not possible to determine if all the key strokes recorded on the GC are from one student or more. During the course of my project one student was sharing her GC with her neighbour in class. She explained how often she was sharing her GC and with who but it transpired she was also allowing others to borrow her GC from time to time. This could mean the analysis of data then becomes much more complex and potentially confusing.

MY PROJECT – some observations

The students within my study were all volunteers and came from two schools. The data was collected by means of interview, students' journals, observations and data from the GCs. Each GC used by the students had Key Recorder running in the background and I was able to observe what use the students made of their GC over the year.

There were several emergent themes that arose from my data and I go into these in a little detail below.

1. Exploring

All of the students at one time showed some evidence of exploring their GC, mostly by pressing keys to find out what functions were behind it. Sarah was the only student who worked with the manual through a selection of examples. She created polar roses; stored numbers into variables and then used these values in a formula. She also tried to save the quadratic formula as a program in the GC but was unsuccessful. This example does not appear in the instruction manual and so indicates that she is aware of some of the potential of the GC and is using or exploring it with her own needs in mind.

2. Learning & Using Specific Features of GC

None of the six students were extremely proficient with their GC at the end of the year although some of them were confident using a very limited selection of features of the GC. For example: all the students eventually seemed to master the ANS and ENTRY functions but only Sarah combined them and embedded the ANS function within a calculation using ENTRY. There is no evidence that the other students attempted this and so it is not standard practice. Even Sarah initially found it hard and attempted it several times before she succeeded.

As mentioned above, Sarah used the manual to perform calculations with the quadratic formula and stored values. She also attempted to save this formula as a program, albeit unsuccessfully. Towards the end of data collection Sarah used a trial and improvement method to find the solutions to a quadratic equation and appeared to have forgotten the earlier work from the manual.

3. Navigating around GC

At the beginning of the year all the students seemed to be struggling to find various features on the GC. It appeared they were trying to 'transfer knowledge' of using a scientific calculator to their GC. At the beginning of the year there seemed to be some indication that they were exploring the GC by scrolling through some of the different menus and pressing different keys to see what would happen. This lessened as the year went on which may indicate that they felt more confident about where functions were on the GC.

4. Navigating around the screen

Within the first few weeks the Key Recorder data indicates that the students were all trying to move around the display unsuccessfully. They all made the same errors at some point: they were trying to transfer their knowledge of computers, and word

processors (WP) in particular, to the GC. After completing an entry they all tried to edit the calculation by pressing UP and LEFT as would be done on a WP but on the GC this is not possible.

5. Errors

Most of the errors that were created by the students were syntax errors and frequently the students pressed CLEAR to erase the error. There are only a couple of instances when a student used the GOTO feature - when the GC indicates where the error may lie. It was usual for the students to either QUIT the error or press CLEAR and return to the HOME screen to re-enter the calculation. Surprisingly, Steve, who was most reluctant to use the GC was the first to take advantage of the GOTO feature when trying to correct errors.

6. Frustration

Some of the students appeared to become quite frustrated with the GC. There are instances when the student wanted to delete or alter a calculation and being unable to they pressed DEL repeatedly, possibly indicating frustration. Sometimes the logical flow of key strokes is questionable or confusing and therefore may indicate that the GC was turned off, maybe through frustration or being unable to exit a menu successfully.

SUMMARY

The way in which the students used their GC changed over the course of the year. They became more familiar with the GC – where different functions were and how to navigate around both the screen and the GC successfully. It also became apparent that the data indicated three different types of learning – learning mathematics; learning how to use a GC; learning mathematics and learning how to use a GC simultaneously. There was little evidence to show that learning of some mathematics on its own had taken place, but there was evidence to show that students had learnt how to use their GC and also that they were learning some mathematics in conjunction with learning about their GC – for example when Sarah investigates polar graphs she is learning about a new area of mathematics and also how to use her GC to draw these graphs.

From my own experience I have seen that only a few students appropriate their GC. Some will perceive and value its potential and are willing and enthusiastic to use it while others will put up barriers and arrive at a state of mind where they appear to reject it as a useful instrument. I think appropriation will have taken place when a student experiences ‘ownership’ of the instrument and adopts it as an instrument. Appropriation will manifest itself as the student willingly and frequently using the instrument whenever they are instructed or whenever they feel it is necessary. If a student has not appropriated the instrument they may be reluctant to use it, may not be able to see its potential for problem solving and may possibly need a considerable amount of encouragement, help and instruction when prompted to use it.

The Key Recorder was a useful data collection tool, allowing access to students’ work in and out of the classroom and it provided details of how the students used their GCs that otherwise would not have been possible. As I have shown above there are many

problems associated with Key Recorder and although the disadvantages do appear to outnumber the advantages, it does provide some unique opportunities for gauging an insight into how an individual uses their GC. It is for this reason I felt able to work around the disadvantages and focus on the advantages of collecting this type of data.

NOTES

1. TI-Connect can be found from the Texas Instruments web-site at http://education.ti.com/us/product/accessory/connectivity/features/software.html last checked 24/5/05

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