The Sherpa-Student Role with a Graphics Calculator: Empowering or Disempowering?

Pat Forster
Edith Cowan University
<p.forster@ecu.edu.au>

Peter Taylor
Curtin University of Technology
<P.Taylor@curtin.edu.au>

Craig Davis
St Hilda's Anglican School for Girls
<cdavis@sthildas.wa.edu.au>

This paper explores student empowerment in the context of graphics calculator usage. The setting is revision and a student has her calculator attached to an overhead projection panel, hence the Sherpa-student role. She is working according to the teacher's instruction. Problematically, she lags the teacher's instruction and another student preempts her answers. In addition, the teacher uses tripartite questioning which can mediate against student empowerment, but a mitigating factor is students disrupt the questioning repeatedly. Use of the overhead panel and the conditions that worked towards and against student empowerment are discussed in the paper.

Introduction

A Sherpa is "a member of a Tibetan people . . . noted for their skill in mountaineering" or, alternatively, "a (mountain) guide or porter" (Shorter Oxford Dictionary). This paper explores the role of a Sherpa-student, which is the term Guin and Trouche (1999) and Drivjers (2000) use for a student who has her graphics calculator attached to an overhead projection panel so that her calculations are available for all to see. Albeit, Sherpas are usually male, but the inquiry in this instance took place in an all-girls' Calculus class, hence the feminine pronoun. Issues are whether a Sherpa-student is likely to demonstrate that she is skilled and guides others through the terrain; or whether she is guided and finds her role a burden. Conditions for positive and negative outcomes are identified in a classroom episode and cast in terms of empowerment and disempowerment of the Sherpa-student and of students in the class as a whole.

The inquiry is part of a classroom-based study over twenty-one lessons. The Sherpa-student role was enacted regularly, at the teacher's request. Moreover, in one instance a student took the initiative and asked for her calculator to be linked to the over-head panel. Other example of practices in the class are reported in Forster and Taylor (2001) and Forster, Taylor and Davis (in press).

The main epistemic referent for the inquiry was ethnomethodology which is founded on the assumption that "the world we live in is established by the mutually related acting of the members of society" (Jungwirth, 1996, p. 5). People constitute and are constituted by the practices of the groups to which they belong. The analysis was informed also by literature on classroom interaction (e.g., Mehan, 1979), use of graphics calculators (e.g., Goos, Galbraith, Renshaw & Geiger, 2000) and student identity and empowerment (e.g., Klein, 1999).

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The Literature: Empowerment and Graphics Calculators

Perusal of research publications and conference proceedings shows that increased attention has been given to social aspects of mathematics learning over the last ten years and some studies have specifically addressed the notion of empowerment or, more particularly, disempowerment of students (e.g., Klein, 1999; Zevenbergen, 2001). One view of empowerment is that students come to "know themselves as competent and numerate persons" (Klein, 1999, p. 310). Furthermore, "numeracy is not a gift but a social practice always in process; it is contextual and always constituted by, and constitutive of learners" (ibid). So, student empowerment resides in how students perceive themselves and how others perceive them. It depends on assuming authority and being accorded authority by others. It is one aspect of students' identity.

Empowerment also develops in relation to cultural artefacts, including the graphics calculator. Goos et al. (2000) suggest students interact with the technology as though it is a *master* (the student vests authority in the calculator, without question); *servant* (the student monitors the outputs of the calculator for reasonableness); *partner* (the student balances the authority of mathematics with the authority of calculator outputs) and *extension of self* (where students incorporate technological expertise as an integral part of their mathematical repertoire--the partnership between student and calculator merges to a single identity). In brief, students' empowerment with the tool, in this analysis, depends on their technical expertise and the extent to which they exert critical attitudes to the outputs.

Goos et al. (1999) identify also that students' attitudes towards graphics calculators and practices with them emerge through the role-model the teacher provides. Nevertheless, a teacher making explicit the limitations of the technology and encouraging students to be critical does not guarantee the same critical and questioning attitudes in students (Boers & Jones, 1994). Non-critical attitudes to calculator results, per se, seem to be the norm (e.g., Zbiek, 1998).

Classroom-based studies elucidate, as well, that instructors can contribute directly to students' feelings of disempowerment in a curriculum where graphics calculators are included. For instance, Povey and Ransom (2000) report that there was widespread feeling amongst students against technology-first approaches in undergraduate courses which emphasised learning with computer technologies, including graphics calculators. Students preferred to do mathematics first by hand, in order to understand the mathematics and to understand what the technology was doing. In *blackbox use*, where students do not have the background to understand calculator outputs, students can feel out of control (i.e., powerless) and, as well, experience frustration and discomfort, and become resistant to using the technology (Drivjers, 2000; Povey & Ransom, 2000).

On the other hand, the introduction of graphics calculators to the curriculum commonly heralds more student inquiry and less expository teaching (e.g., Farrell, 1996). That is, introduction of the calculators can result in students' exerting more self-determination and empowerment in regard to their mathematics, provided suitable activities are provided to support them (excluding, e.g., blackbox calculator use).

The inquiry reported in this paper is about student empowerment/disempowerment as constituted in whole-class work, in relation to use of a graphics calculator attached to an overhead projection panel. Goos et al. (2000) identify student empowerment when *teachers* use the panel to demonstrate calculator operations and problem solutions, examine alternatives, and enlist student participation; and when *students* use the panel to demonstrate calculator operations, present findings and share partial solutions.

In the instance presented in this paper, the context was revision. A student was operating her calculator with it linked to the projection panel while sitting in her normal seat, which was a normal practice in the class, made possible by a long lead. The student worked in tandem with the teacher's instruction. Drivjers (2000) describes a similar practice, where a pair of students in their seats used a calculator attached to an overhead panel for an entire lesson. The setup was put in place for research purposes and different student-pairs were selected each lesson. A "side-effect of this was that other students could also see what 'today's victims' were doing" (p. 196). We wonder who/what were they victims of? This issue is a thread in our inquiry in the revision setting.

Research Methodology

The main epistemic referent for the inquiry of which this paper is part was ethnomethodology (e.g., Jungwirth, 1996). Thus, patterns of interaction in the Year 12 Calculus class were sought, as evidenced in the twenty-one consecutive lessons during which the first author was an observer-participant. She observed whole-class work and, as well, set a video-recorder to record continuously and included the display from the overhead panel in the field of view. During seatwork she acted as an assistant teacher, which gave her opportunities to observe and note students' individual use of their calculators. Other data were collected but are not relevant to this paper.

The epistemic status of the analysis is that it was conducted by the first author with critical advice by the second author and was checked by the third author, the teacher, to establish that he did not object to it. The episode presented in the paper is anomalous because the Sherpa-student did not appear competent, whereas having their calculators linked to the panel was usually a means through which students displayed competence (e.g., Forster, Taylor & Davis, in press). The episode is reported on pragmatic grounds, to elucidate the problems that can occur in the Sherpa-student role.

Importantly, and consistent with the assumptions of ethnomethodology, it is assumed (a) the Sherpa-student determined the classroom action, as did all students and the teacher, (b) participants were not necessarily aware of the nature of their actions and (c) the research method did not require that participants personal responses be ascertained. Ethnomethodology is an interpretative methodology and the research account is known to be personal those who write it (Roth, 1998).

A Classroom Episode

The teacher, Mr D, is leading a review of compound interest, prior to introducing continuous growth relationships. He asks for the amount in a bank account at the end of the first year if \$100 is invested at an interest rate of 100% per annum, with yearly compounding. A student provides the answer (\$200). Mr D writes it on the board.

Next, he restates the question with six monthly compounding and hands Emily the lead to the calculator panel. Tanya gives the answer (\$225). Mr D asks Tanya to explain her method and writes it on the board. The questioning and writing up continue for quarterly compounding (see Figure 1).

p.a	Amt = 200
6 mth	100×1.5^2
3 mth	100×1.25^4

Figure 1. Written solution on the whiteboard

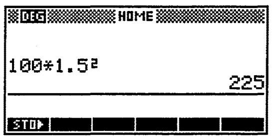
Mr D turns to Emily and asks:

1. Mr D How much do we get there Emily when we do it every six months?

Emily starts the calculation and Tanya responds:

2. Tanya 225.

Mr D writes up the 225 and the screen display from Emily's calculator appears on the whiteboard, to the left of the written solution (see Figure 2).



p.a	Amt = 200
6 mth	$100 \times 1.5^2 = 225$
3 mth	100×1.25^4

Figure 2. Screen display and written solution to the problem.

3. Mr D And what about when we do it by 1.25 for every quarter?

4. Emily $244.14. [The screen display relayed from her calculator changes on the board]

5. Mr D $244.14 [writing it up]. So what is starting to happen here?

6. St It's getting bigger.

7. Mr D It's getting bigger.

Mr D asks for the amount with monthly compounding. He nominates a student to answer and after prompting she gives the expression $100(1+1/12)^{12}$. Mr D asks:

8. Mr D So, how are we going there Emily [looking to the overhead display]?

9. Tanya It's 261.30.

10. Mr D Yes [as Emily finishes]. Emily has it there. 261.30 [writing it as he speaks]. So it has increased again. Is this always going to keep getting bigger? If I go to a really generous bank, will they have to pay out an infinite amount of money to me?

11. Chorus Yes [gleefully].

12. Mr D Okay. Let's go to the next bank and say they calculate the interest daily, and this is how most banks tend to operate. So, how will I calculate it this time. Alex?

13. Alex 100 x 366/365.

14. St What?

15. Mr D Ohh. Hang on. So, here it was 100 [%], so, we divided by twelve. And then it's?

16. Alex 1+1/365.

Widespread chatter erupts.

17. Mr D Yes. So, you are one step ahead of me. So, 1/365 [writing $100(1+1/365)^{365}$ on the board]. Okay. So you are correct in what you are saying there. Now, because we are going from 12 times to 365 wouldn't we get a huge big jump because we are doing it a lot more times?

18. St But the fraction inside is getting smaller.

19. Mr D Okay, but what do we get [looking at the overhead display]? 271 point

20. St 46 [reading it off the display].

21. Mr D 271.46. So, what is starting to happen here? Why isn't it starting to get proportionally bigger here? It is approaching?

22. St An asymptote.

23. Mr D Better than that, say? [pause] It's approaching a limiting value. Anyone know what the limit is? [pause]

Students talk to each other: "e divided by 100", "100 times e", "e times 100" . . .

24. Mr D Okay. Let's do it by the minute. By the minute we do . . . [writing and speaking $100(1+\frac{1}{365\times 24\times 60})^{365\times 24\times 60}$]. What do we get when we do that?

25. Tanya 271.83. [Emily is keying in the expression to her calculator]

Mr D looks at the overhead display, waits for it to change and writes 271.83 on the board.

26. Mr D Well, it certainly is approaching a limit. Let's say we go to a super generous bank and say they are going to compound your money all the time. [students laugh] . . . What will the amount be?

27. St 100 times *e*.

28. Mr D Yes, 100 times *e*.

He discusses the definition of *e* and the use of it for continuous growth situations; and the screen display changes, see Figure 3.

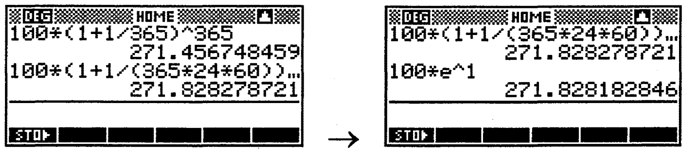


Figure 3. Compounding by the day and minute, changing to show the result for 100*e*.

29. Mr D . . . Yes Anna.

30. Anna The one above is bigger

31. St Yes, that is what I was about to say.

32. Mr D So, the top one is slightly bigger, is it [looking at the overhead display]?

Widespread chatter erupts.

33. Mr D Oh, I know why. It's probably because

34. Tanya Oh, Mr D. It isn't bigger on mine.

Students laugh and the noise level rises.

35. Mr D No, the definition of *e* is this formula . . .

36. Tanya Well, I will do the calculation again, what I did was calculate $365 \times 24 \times 60$ first.

37 Mr D Did anyone else do that?

38. Sts Yes.

39. Mr D Well that's interesting. I will have to think about that. Can you guys think of a good reason?

So, was Emily--the Sherpa-student--a victim; and, if so, what were the circumstances of her victimisation? We consider these issues below and the social conditions amongst the class, in general, that worked towards students' empowerment/disempowerment.

Emily

Having her calculator linked to the panel gave Emily an opportunity to demonstrate her abilities and have them recognised by the class. However, generally she appeared to lag rather than lead the calculation. Lagging arose because, first, she didn't start calculating until the teacher prompted her (turn 1). She did not follow the normal interaction pattern in the class of starting soon after being given the lead. The delay in starting, therefore, could be classed as an instance of *interactional incompetence* (Mehan, 1979).

She caught up temporarily (turn 4), then, fell behind again (turn 8), or appeared to fall behind, for Emily's slowness was relative to the speed with which Tanya stated the answer (turn 9). However, the teacher did not pay attention to Tanya's response (turn 10). Ignoring or not paying attention to students who speak out of turn is a way of signaling that interruptions are unacceptable (Mehan, 1979). However, Tanya did not seem to take the signal on board for, later, she again preempted Emily's calculation (turn 25).

What can explain the difference in the two students' speed with the calculation? Maybe a barrier to Emily keeping pace with the monthly compounding was that she couldn't predict the method. It required the use of a fraction (1/12) instead of the decimals used earlier, and not recognising this could be said to indicate *academic incompetence* (Mehan, 1979), for the subject matter had been met previously. However, this analysis is perhaps too harsh, for the student who was nominated to answer stumbled in articulating the changed pattern.

Then, in regard to compounding by the minute, it became apparent (turns 36-38) that Tanya and others used their calculators more efficiently than Emily. Calculating $365 \times 24 \times 60$ first and then copying it down each time saves several key-strokes and so saves time. By keying the product twice, Emily showed *less technical expertise* than the other students.

Hence, the episode illustrates that a Sherpa-student faces interactional, academic and technical demands. The episode illustrates also that students' personal competence/ incompetence, which translate to empowerment/disempowerment, are socially determined, in relation to and in relationship with other students. Moreover, relative competence and incompetence evolve and are not established in a single short episode.

Other salient aspects of the episode are that Emily appeared calm throughout (and not as though a victim), her relative slowness benefited others in that she moderated the pace of the solution, and she finished by showing initiative and calculating 100*e*, in a timely way. Furthermore, Mr D had a central role in the episode which is discussed below, where attention is given to conditions for student empowerment in general.

Mr D

In this episode, Mr D used a tripartite questioning style: teacher elicitation, student response (usually short), and teacher evaluation leading into the next question (Mehan, 1979; Young, 1992). According to the literature (Young, 1992), it is a pattern whereby students produce the answers the teacher intends upon framing the questions and typically, at least in middle-class groups, students know and play the game (Zevenbergen, 2001). The mode of interaction is consistent with tight teacher-control and was the style Mr D consistently used for revision.

Alex's response in turn 13, however, caused disjuncture in the questioning. It fitted the pattern of a *too complete description* (Jungwirth, 1996). Alex didn't keep to the pattern that was in place, $100(1+1/365)^{365}$, but instead went to a simplified version. Teachers typically unpick the condensed (or simplified) answer with the student's assistance, as Mr D did here (turn 15-17), and then reinstate control and order in the questioning. In the process, the student who answered can be left looking incompetent, as though she couldn't articulate the solution properly, and the solution can appear to be the teacher's. However, here Mr D finished by acknowledging and affirming Alex : "So, you are one step ahead of me . . . So, you are correct in what you are saying there" (turn 17). He regularly did return to give students credit and when he didn't, students sometimes insisted, on behalf of each other, that credit be given.

Anna's observation about the value for 100*e* (turn 30) disrupted the proceedings again. It is an example of the critical questioning that is required towards calculator outputs (Boers & Jones, 1994) and can be cast as a student exhibiting mastery (Goos et al., 2000) over the calculator instead of the calculator being master to the student. Furthermore, the teacher afforded the discrepancy high recognition (turn 32-33, 35, 39), which potentially drew more attention to it and fostered critical attitudes towards calculator outputs amongst the class. However, other than Tanya who mentioned the order of calculation, no other student offered an explanation, but Mr D did. The difference was due to rounding. The Hewlett Packard calculator that most students were using rounded to fewer places than Tanya's Texas calculator. The intermediate calculation '$1+1/(365\times24\times60)$' (see the full expression in turn 24) would have been rounded and when raised to the power of $365\times24\times60$ the rounding error was amplified.

In relation to Emily, Mr D's acceptance of Tanya's early response (turn 2) gave Emily time to catch up. Then, after the first interruption, Mr D's waiting, looking to the display and obtaining the answers from it (turns 10, 19, 26, & 32), were consistent with Emily having the responsibility and right to provide the results to support the class work. In other words, the teacher's actions accorded Emily the role of chief-Sherpa.

Another notable aspect of the episode is that six students, in addition to the four who have been named, contributed to the discussion: at the beginning a student questioned the compounding period and others answered in turns 6, 14, 18, 22, 27, 30, and 38. Turn 18 was insightful and turn 30 was further evidence of critical thinking, while turn 38 showed students were performing the calculations themselves and not relying on the projected display. As well, the episode was punctuated by chatter between students (after turns 16, 23 & 32). This was a regular and potentially empowering practice in the class for more students expressed their views through it than was possible during whole-class discussion. As well, the chatter fed into whole-class discussion and, at times, advanced it (e.g., turn 27).

Thus, a large majority of students in the class of 13 participated actively in the episode and their participation wasn't all low quality, which can happen with tripartite questioning. Mr D's acknowledgement of students' unexpected answers (interactively demanded by them), support for the Sherpa-student and pursuit of the source of error can be seen as enabling aspects of the revision in as much as the actions are consistent with encouraging students' active and critical participation; and, so, are potentially empowering.

Concluding Discussion

So, did Emily--in the Sherpa-role--guide others or was she guided? Generally, she appeared to lag rather than lead, partly because of being unusually slow to start and partly because she was pre-empted in calculation by another student. Near the end, though, she took the initiative and entered 100*e*, which revealed the inconsistency with the calculator processing for all students. The public display led also to the strategy 'multiply $365\times24\times60$ first' being identified, for the potential benefit of other students.

Emily's delay in starting calculation was cast in terms of interactional competence; and interactional competence, as such, was shown to be determined also by the actions of others. In addition, Emily's apparent academic competence and technical expertise were identified in relation to other students' actions. In summary, the analysis according to these three dimensions of competence portrays her as being guided more than being a guide in the episode.

Drivjer's (2000) suggestion that students in the Sherpa-role might be victims also needs consideration. Was Emily a victim? Was she subjected to *cruelty, oppression, or other harsh or unfair treatment* (Shorter Oxford Dictionary)? Emily was not unusually singled out by the teacher for a student having her calculator attached to the panel was a normal practice in the class, and the teacher supported her in various ways during her performance. She was, however, subservient to the revision agenda.

In other episodes, having their calculators linked to the overhead panel seemed a powerful and empowering means of communication to students. Empowerment more than victimisation seemed operational in the Sherpa-role in the Calculus class, particularly when Mr D moved from tripartite questioning, to discursive, open questioning (see Forster & Taylor, 2001). Aspects of the classroom practice evidenced in the episode discussed here, including critical questioning of calculator outputs, were also consistent with empowerment.

In conclusion, it can be argued that the appearance of competence /incompetence in a single episode has low significance. However, repeated instances of a student performing in public and the class having to wait could adversely effect how the student perceives her own competence. Our micro-analysis of the episode had the purpose of raising awareness of how this negative outcome might occur.

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