Hewitt, D. (Ed.) Proceedings of the British Society for Research into Learning Mathematics (25(3) November 2005
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STUDENTS SETTING UP THEIR OWN BUSINESS – A MATHEMATICAL ACTIVITY

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How does a plumber determine what his/her hourly rate should be, or a hairdresser determine how much to charge for a haircut? If they go to a bank for a loan, then the manager will want some assurances that the rates charged will keep the business afloat. We describe the work some Year 9 and 10 students did as they engaged in these activities and set up their own virtual business and discuss aspects of the work.

INTRODUCTION

We report on work that Linda undertook as a teacher-researcher in a project *Linking School Mathematics to Out-of-school Mathematical Activities*[1]. This paper is in three sections. This introduction continues by outlining the project first from John and Louise's and then from Linda's point of view. The second section describes the work in three parts: its origins, what went on and outcomes. The paper ends with a discussion of: the role of outside people, the use of technology, issues relating to repeating the work and issues for functional mathematics.

One project, two perspectives

The project explores ways that secondary school mathematics can be done in a manner similar to (or be 'linked to') how it might be done in out-of-school activities. The aims are to understand: how these links may be made; how learning activities can be designed; the use of teachers and resources; what learning takes place. That, at least, is John and Louise's perspective. Although there is a mutual appreciation of the project work, university-based researchers and teacher researchers will come to the project with different agendas.

Linda entered the project with a desire to:

- To inspire and motivate students of all levels.
- To show students that maths is something which happens *outside* school too.
- To appreciate the wide range of activities which are based on mathematical ideas and ways of thinking.

CLASSWORK

Origins

As a year 11 form tutor Linda talked with her students about what they wanted to do after year 11. Several wanted to form their own business – a franchise arrangement or using a skill, e.g. a builder or a decorator. This was the spur for this work. A family friend (Jim) was a retired bank manager who had reviewed applications for loans to start up businesses. Linda thought it would be great for the kids to have an expert in the room to initiate and then evaluate work on starting up their own business. On

their first meeting it appeared that what Linda had in mind was too big – both in terms of preparing a business plan and in terms of letting them all choose a business. It emerged that what Linda wanted to do was akin to what Jim called 'sensitivity analysis', where variables could be changed (using a spreadsheet) to prepare 'optimistic' and 'pessimistic' approaches to setting up a virtual business, e.g. if you change the interest rate on the loan for van, then how does this affect profits? Linda and Jim chose plumbing as the business because they thought it would be familiar to the students (they will have seen a plumber at home) and it is a job which does not require any premises – trying to reduce the number of variables at this stage.

Linda and Jim worked with a year 9 class and then with a year 10 class where students also addressed setting up their own hairdressing business (which is actually more tricky than plumbing). Due to space restrictions we report only on the year 9 work in this paper.

What went on in the classroom

Linda introduced the project to the students by providing an overview of the project and what their involvement would be. The students responded positively and discussions began as to what sort of costs needed to be considered by a plumber when setting up in business. Linda and Jim introduced the idea of fixed and variable costs as well as essential and optional costs and the students began to consider what costs they could think of that would fall into these categories. Figure 1 shows some board work when Linda collated students' ideas. The presence of an outside expert in the class seemed to focus the students and there was a great deal of animated discussion about the costs. The students were asked to create their own posters in pairs with information about the costs that would be incurred and which category they would fall into.

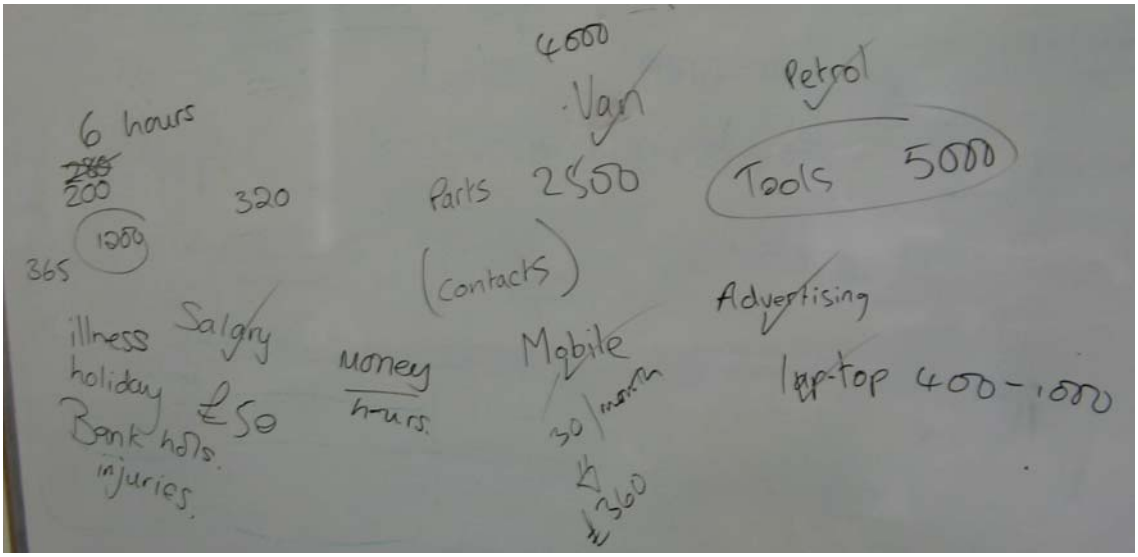

Figure 1. Board work, students' ideas about costs

For homework the class were asked to consider what vehicle they would like to use for their business. They were asked to research what vehicles were available and any credit terms or bank loan details that would enable them to make a purchase. Many of

the students used the internet to find information and there were many ideas for a suitable vehicle ranging from an articulated lorry through to no vehicle at all – instead suggesting that they could use public transport!

The next session was in the IT suite where the students were introduced to the first of two spreadsheets. This spreadsheet allowed the students to enter the potential costs and provided them with optimistic and pessimistic views on income and outgoings for the business. After a short while it became apparent that some of the students had trouble understanding the spreadsheet as they did not understand the terms 'optimistic' and 'pessimistic' and could not understand why there were three amounts for each cost they entered on the sheet (their cost, the optimistic cost and the pessimistic cost). It also became apparent that within the group of students there were different levels of competency with working on spreadsheets.

The second spreadsheet was much more sophisticated and was a slimmed down version of one that small businesses use to track their expenditure and income and make projections for the future. This spreadsheet had been designed by a friend of Jim who sold this version to different businesses. It had various worksheets called 'working days', 'annual staff costs', etc. linked to a main worksheet called a 'dashboard'. Figure 2 shows the 'working days' worksheet and part of the 'dashboard'. This seemed a little advanced for the students but it allowed them the opportunity to consider how many days and hours of work they could fit in a year taking into account holidays, public holidays and sick days etc.

	Public Holidays	Weekends	Annual Leave	Illness/Other		
Input…..	8	104	15	5	Working days	233

How many working days do you forecast in a working year?	233
How much do your premises cost per year?	£6,200
What are your professional services costs per year?	£25,000
What does it cost you to buy and maintain transport per year?	£14,760
How much do I want to make on materials (over cost)?	20%
What do you forecast annual cost inflation to be?	5%

Figure 2. The 'working days' sheet and part of the 'dashboard'

Jim attended every session to help the students understand the intricacies of costing the setting up of a business. However by the end of the project Jim's role changed from being an 'outside expert' to being a co-teacher.

Outcomes

How do you judge the success of something like this? Give them an end of unit test? Certainly not! We would like to note that this was a first attempt at an activity that we

will refine and repeat in the coming year. Our evaluation of this first attempt is rather 'rough and ready' but it is honest. In terms of student engagement the work was a success. It is very difficult to get a measure for student engagement but it is very easy to 'know' when students are enjoying themselves and applying themselves to the task at hand; and this was the case here.

In terms of students developing their own correct answers (there were, by the way, many different correct answers) the situation was extremely variable, though we feel that everyone constructed some relevant mathematics. Before continuing we outline the essence of an important part of the task – calculating an hourly rate, encapsulated by the expression on the right. This expression was not presented to the students in this symbolic form but everyone attended to it in a way they understood (for one year, you add up all the various costs incurred, add on the salary you need and then divide this by the number of hours you expect to work; this should give you a 'break even' hourly rate). At one level the mathematics is not difficult (various additions and a division) but constructing the calculation from the situation is challenging.

$$\frac{\text{yearly salary} + \sum \text{costs}}{\text{hours/year}}$$

A problem in evaluating students' answers is judging how much they did themselves. Clearly a role for Linda and Jim was to help students 'do it themselves', but when does such help become 'the adult doing it for them'? The following is an extract from a discussion between Jim and a student. Prior to this discussion Jim, with class participation, obtained 1560 as an estimate of the hours worked per year.

S: 1560 err I don't know what that is. Is it the number they wrote on the board there? Where did that come from?
J: Well, there are 233 days of the year after you take bank holidays and everything off and 8 hours per day, but you've got in a month 155 hours, but 25 of those are spent travelling between the job so you've got 130 hours. Twelve times 130 is 1560. OK?
S: So that's your total of all those divided by.
J: That's your total and it's divided by 1560 gives you that, and that is the hourly rate you would have to charge to be able to pay all those costs and pay himself a living wage
S: So he gets his costs… right, OK.
J: So what would he actually charge then?
S: For his hourly rate?
J: Yes.
S: £29.49
J: Do you think a plumber would actually charge that?
S: Well that's probably the reasonable charge.

DISCUSSION

The role of outside people

Jim played a crucial role in this work: without his help we would not have had a real-life task and his presence motivated the students. This student-motivating factor of

outside people has been commented on elsewhere in the wider project work (see Monaghan and Staneff, 2005). Why and how do 'outside people' motivate students? At this stage in our work we only have hypotheses and counter hypotheses. (i) There is a novelty element to any 'new face' in the classroom; against this Jim's authority extended beyond the usual 'honeymoon period' of, say, new teachers. (ii) The 'type' of outside person likely to motivate students will vary according to the 'identity' of students (a bank manager for some but a plumber or hairdresser for others). (iii) The form of 'boundary encounters' (Wenger, 1997, p.112) may be important. Jim was a visitor from another community of practice. Wenger (ibid.) states that "The host practice is unlikely to witness in any significant way how visitors function in their home practice."

Unlike the other outside people who played a part in the wider project Jim did not remain the detached expert but developed into a co-teacher. Apart from admiring this at a personal level, what interests us is that he assumed a dual role, he retained his 'expert' status whilst teaching.

The use of technology

ICT is an increasingly important part of employment (see Felstead, Gallie & Green, 2002) and although this work could have been done without using ICT, a spreadsheet appeared to all of us as an appropriate tool for the task. Further to this, and as mentioned above, a special spreadsheet would be used by a small business advisor to assist clients, so ICT use helps make the task realistic. The professional spreadsheet, however and as mentioned, was, in our opinion, too advanced for the students (and most plumbers too). Our intentions for the repeat of this work is to produce a simplified template (which students may alter if they wish) of this professional spreadsheet that restricts the variables to: yearly salary, sum of annual costs, working days/year and working hours/day. We hope that this will lead to a calculation for the number of hours worked in the year and, in turn, to the hourly rate.

Issues to attend to in repeating this work

There are two foci, designing learning experiences and researching this learning. With regard to the former and changes we will make when we repeat this work, we will pay careful attention to language issues, e.g. optimistic and pessimistic, and, as mentioned, produce a simplified template of the professional spreadsheet. Our aim is for all students to calculate the hourly rate themselves, so we will allocate plenty of time (perhaps a homework) for this. Other areas where we can use homework are researching transport costs, reasonable hourly rates and local property rental costs. We will also endeavour to bring a plumber into one lesson to talk to the students.

With regard to research Louise and John observed all the lessons (and made free use of a digital camera and voice recorder) and conducted interviews with Linda, Jim and selected students. They were not, however, satisfied with the data they collected – it was too selective (reactive to interesting things going on in the class). To rectify this they will, with the students' permission, position a number of voice recorders to pick

up (virtually) all of the students' discussions and install 'screencam' software (see Weigand & Weller, 2001) on the computers to capture students' spreadsheet actions.

This work and functional mathematics

At the time of writing the future of 'functional mathematics' (see Roper et al., 2005) is being discussed. Various models of functional mathematics are being put forward. Hoyles (2005) views functional mathematics as modelling:

> ... a way to make sense of the world. It involves analytical reasoning, and understanding algorithms. Increasingly, people at work and in everyday life have to interact with models, interpret their output, understand their inputs, be able to add or tweak variables, know what does and does not follow from them.

We consider our work as consistent with this view: it requires students to 'make sense of' an aspect of the world, the costs of setting up your own business; the reasoning involves quite deep mathematical thinking, establishing relationships; even though students are not expected to construct the expression in the algebraic form shown above, they are expected construct this in their own way on a spreadsheet and then 'tweak' the variables.

ACKNOWLEDGEMENTS

This work was supported by the Economic and Social Research Council, Award Ref. No. RES-000-22-0739. Thanks and respect from all of us to Jim Chadwick.

NOTES

[1] See http://www.education.leeds.ac.uk/research/cssme/outofschool.php for the project description.

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