Preparing students for the extended numeracy demands of the modern workplace

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Investigations were carried out at a Further Education college in Wales to determine the extent to which students are prepared for the numeracy demands of employment. Surveys were carried out with teaching staff and students of courses including: science, computing, business studies, and construction. It was found that a majority of students would require additional job-specific training after entering the workplace, but that further help could be provided in college by developing the wider transferrable skills of numeracy, including: mathematical methods, problem solving, data collection and processing including the use of electronic devices, and effective communication of mathematical results. Students showed greatest motivation when undertaking authentic real-world problem solving tasks, particularly when personally involved in the design of a project and collecting their own data for analysis.

Keywords: numeracy, workplace, motivation, community of practice

Introduction

There is concern by the Welsh Assembly Government that students leaving education and entering the workplace are inadequately prepared for the numeracy tasks they must undertake in their everyday work.

The survey reported in this paper forms part of a project to improve the numeracy skills for employability of students undertaking level 3 courses within a range of subject areas.

A distinction is made by a number of researchers (Hoyles et al., 2000; Dingwall, 2000; Coben, 2000) between mathematics, which is taken to be a set of quantitative methods, and numeracy which has wider links with the real world. Numeracy need not be at an elementary level but might include, for example, the advanced mathematics used by engineers or scientists. Numeracy requires knowledge of the real world context in which the problem occurs. It is essentially a practical problem solving activity drawing upon appropriate mathematical techniques, and the results obtained often need to be communicated to others in a way which is useful for decision making.

Hoyles et al. (2000) have summarised the mathematics related qualities required for the modern UK workforce, which they suggest go well beyond the use of number. In addition to knowing how to calculate and estimate and to have a feel for numbers, percentages and proportions, the skills required include:

- analytical, flexible, fast and often multistep calculation and estimation in the context of work (with and without the use of IT tools)
- complex modelling (of variables, relationships, thresholds and constraints)
- interpreting and converting between different representations of quantitative data, using number, graphs and algebraic expressions as appropriate.
- systematic and precise data handling techniques using IT systems.

- trend prediction and monitoring of models relating to different types of work activity.
- concise, clear communication of judgement
- recognising unusual effects and errors in answers

There is an escalating need for employees at all levels to interpret computer outputs. 'This requires developing Techno-mathematical Literacies (TmL): technically-oriented functional mathematical knowledge, grounded in the context of specific work situations.' (Bakker, Hoyles, Kent and Noss , 2004).

Many numeracy skills may be dismissed as 'just part of the job', being inextricably bound up in work practice. In a study of warehouse workers (Keogh, Maguire and O'Donoghue, 2010), manual employees did not consider that they made much use of numeracy in their daily work. It was discovered that they did in fact carry out many complex tasks falling within the broader definitions of numeracy given above, such as:

- Accessing from computers the data which specifies items to be collected and their storage locations.
- Planning efficient routes around the warehouse to collect required items in a minimum time,
- Estimating the weights of the items required, in order to make up safe truck loads,
- Dealing with the reporting and reordering of items out of stock,

all done under time pressure, with serious consequences in the event of errors.

Invetigation of student numeracy activities

A questionnaire survey and interviews were carried out with teaching staff in a Further Education College in Wales to determine their views on students' levels of numeracy as a preparation for employment. The questionnaire survey was delivered to staff who are teaching a range of vocational courses including: construction, catering, health and social care, and business studies. Interviews were carried out with senior lecturers in engineering and business studies.

Interviews were carried out with students to investigate which numeracy activities during their courses were perceived to have been beneficial. The students interviewed were from groups studying: construction, business studies, catering and a variety of A-level subjects.

Findings

Opinions of staff were collected on how well prepared their students would be for employment. A sample of nine teaching staff from seven vocational subject areas considered that their students were generally not yet prepared for the numeracy demands of the workplace:

- A minority of students would be able to undertake all or most workplace numeracy tasks with confidence.
- Less than half of all students would be able to undertake routine workplace numeracy tasks confidently.
- All students would be likely to require substantial on-the-job training before being able to undertake typical workplace numeraqcy tasks.
- Half of all students are likely to be limited in their choice of occupation or career due to difficulties with numeracy.

These results were generally to be expected. Research authors disagree about the extent to which numeracy can be taught as a transferable skill outside of the workplace. For example: it is difficult to directly relate the skill of operating a Computer Numeric Controlled lathe to the topics in school mathematics. There are, however, a variety of transferrable numeracy skills involved, for example: geometry for understanding tool paths, algebra for program commands, and number for checking measurements.

In practice, specialist training will generally be required when the student enters employment, and as an on-going process of skill-updating as new technologies are developed. Students can, however, be helped by being introduced as far as possible to modern workplace practice whilst studying college courses.

Senior lecturing staff were asked for their opinions on the problems of delivering student numeracy within vocational courses. Integration of numeracy was seen as a desirable objective, but could be prevented by poor student mathematical ability:

> It makes far more sense to teach numeracy, and literacy if it comes to that, through the subject, as students can see the relevance to their real life work. Having said that, there may be a problem in that the standard of maths is so poor that if they haven't grasped the basics then they cannot cope. You may have to take them out, unfortunately, to get those basics. But in an ideal world, applying numeracy to engineering or carpentry or whatever course they are doing is far more meaningful.‘

The current Essential Skills Wales provision was not considered adequate to overcome student difficulties in numeracy:

> I would say that Essential Skills at the moment goes nowhere near what we would want as a successful outcome for numeracy. Something I would do with the students in the first year is to draw up a program to calculate wages, including National Insurance, pension contributions and so on, which needs an understanding of percentages. What I found was that students coming from the National Curriculum could calculate 5% or 10% if you told them what to do, but they couldn't understand and develop the problem for themselves. Their numeracy ability fell short of being able to apply concepts in a real situation.

This observation is consistent with the findings of a report of the Advisory Committee on Mathematics Education (2011): “A frequently heard comment was that too many young people have only learned to do the sort of questions that are set on GCSE papers.”

Views were expressed by the lecturers on approaches to teaching and assessment:

> What is required is much more of a team approach to the teaching of a course. Teachers tend to work in isolation. This is my module, somebody else teaches another module. Numeracy might be taught by someone else again… If these people sat down around the table, they could see how their own modules fit in with other parts of the course. The numeracy would be more relevant, and could be designed to fit the vocational requirements. You could still take the numeracy part and the vocational part and assess them as separate components, but it would be one integrated piece of work.

Continual assessment was generally the preferred assessment option, but external examinations were still seen as an important control on standards:

> I think it is far easier in terms of getting people through the course if the work is continually assessed, and it is assessed through assignments - this certainly suits some people. A well designed assignment can stretch the students, it can pose a challenge and it can be made relevant to real life, and it's a substantial piece of

> work. On the other hand, it is possible to get other people to help. There are problems with authenticity. I think there is a place for formal tests and examinations; I think you need a combination.

Students were asked for their opinions on numeracy activities they had undertaken in the college as part of their courses. They enthusiastically described numeracy tasks in which they had been involved and which they clearly found worthwhile and interesting:

> During physics classes we were told to create contraptions to demonstrate different physical laws. I made a crane to prove the principle of moments. I had to add a counterweight on the opposite end to the main weight to maintain equilibrium.
>
> For computing I am producing a program which is a solar system simulation. I contacted Aberystwyth University, who gave me a table of data on the geometry of the orbits of the planets.
>
> In business, we are doing trial balances and balance sheets. We are also working on financial gearing ratios which I find interesting and will help me in the future.
>
> We had to take part in an enterprise challenge, where we had to sell products to make a profit. We had to calculate the budget to buy equipment and ingredients. I felt that this challenge has improved my numeracy.
>
> I carried out a task planning for a new kitchen, a new bathroom, modernising the flat, and repairs to the roof. I estimated the costs and planned the work to do in the workshop and on site. This helped me with my arithmetic, percentages and estimation, and will make work in my trade a lot easier.

A clear preference was shown for practical numeracy. Responses demonstrate the value of allowing students to choose, design and take ownership of tasks, as a means of increasing motivation.

> In physics we have practical sessions. These are fun. We get experience in setting up electronic measuring equipment and see where the data is coming from, and we understand how errors can happen. We have to use the appropriate formulae and sometimes modify these to get the right answers.
>
> During electronics lessons we conduct experiments, usually involving multimeters to test voltages and resistances in circuits under different circumstances. These experiments nearly always involve numeracy. We would take the data and create a graph to show the relationships, or use formulas to analyse the data. I find this a very effective and enjoyable way of working using numeracy.
>
> Computing lessons often require us to solve a mathematical problem with a program, but we are not give any clues on how to solve it as they are all different. Therefore we have to identify the numbers and try to create a formula to give the correct answer. This is fun, as it allows us to think and find ways to solve a problem that we understand – because we have created the solution method ourselves.
>
> I find maths easy in the workshop and it's interesting and useful.

Students expressed less interest in numeracy tasks which were not presented in a practical vocational context:

> In work that isn't practical, I feel that the numeracy is not as interesting. This is because I enjoy collecting data in the first place and feel more inclined to work with it. Mathematics involves numeracy, of course, but it is not applied to the real world nearly as much as in other subjects.

> Exams and traditional theory work give the students the impression that they are being fed information as opposed to learning it. To get them engaged, you have to get them involved with collecting the data itself.

The Essential Skills Numeracy course was not seen as useful by many of the students interviewed:

> Although I can see the reasons behind Essential Skills Numeracy, doing science courses means that I am working with numbers and it is of little value to me. The requirements for it are very basic, so I find it very dull. My suggestion for improving it would be to integrate it with students' courses, so that they could complete the work along with their other subjects as well as learn new maths which is useful for those subjects.

Discussion and Conclusions

Studies of workplace numeracy have demonstrated that students entering employment require a wider range of skills than mathematical techniques alone. It is necessary to analyse problems, decide on the data required for their solution, and to collect and process this data – often with the use of electronic technology. It is necessary to communicate mathematical results effectively in a form that can be used for decision making.

Surveys of teaching staff suggest that a majority of students are not fully prepared for the numeracy demands of the modern workplace when entering employment. This is not surprising, as many numeracy tasks are specific to particular occupations, and in-service training will be provided by employers. However, the college can help students by developing their general mathematical ability, and also wider transferrable skills in numeracy such as: problem solving, team working, collection and handling of data. It is also of value to provide training using most up-to-date work practices.

Students are generally willing to undertake whatever numeracy activities are required of them during their courses. There are clear differences, however, in levels of motivation for different numeracy tasks. Practical activities in which students plan their own solution methods and collect their own data are most effective, particularly if the students have had some freedom in the design of the problem to be investigated. Less motivating are problems which are highly constrained, with all necessary data supplied to the student and a specified method of solution required.

A teaching approach which appears to work well for students is an adult learning model consisting of three components which are often combined (Figure 1):

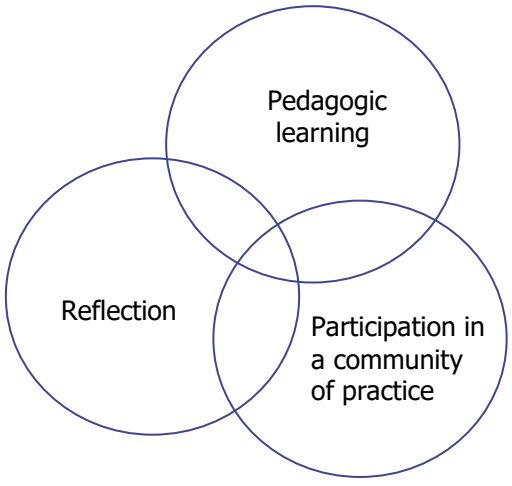

Figure 1. Adult learning model

- Pedagogic learning describes formal study in which a teacher provides the core knowledge required in a subject.
- Participation in a community of practice refers to the way in which students learn from experienced practitioners within a practical apprentice relationship (Lave and Wenger, 1991; Eraut et al, 1998).
- Reflection describes the way in which students make sense of events and learn through experience (Boud and Walker, 1998).

Mathematical modelling may provide a successful bridge from pedagogic learning towards a realistic simulation of participation in the community of professional users of mathematics. Modelling, through its handling of ill-defined systems, allows opportunities for reflection, team working and problem solving. A useful theoretical framework around which to plan and conduct mathematical modelling activities has been provided by Blum and Leiß (Keune and Henning, 2003).

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