Basic Mathematical Skills: Are they important?

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All students studying a quantitative course in higher education need certain basic mathematical skills that depend on the syllabus being followed. For a variety of reasons, many students are entering higher education without the requisite competence. Unless action is taken now the problem will cascade beyond this generation of students.

In the United Kingdom there are several reasons for this diminution of basic skills. Cockcroft in 1982 published a report which, since that time, has influenced school education, and by extension, higher education. He suggested that all lessons in mathematics should contain six elements, namely exposition, explanation, exploration, examination, exercise and expression. In schools it became unfashionable to concentrate on exercise by which he meant the reinforcement of basic skills. The changes in teaching style resulting from the Cockcroft report meant that traditional text books were replaced by patronising cartoon like books where there were fewer examples on which the students could hone their skills. In addition, since that time, the pocket calculator has become ubiquitous in the mathematics classroom and cheap enough for most students to purchase. Many now pick up a calculator to multiply 6 by 7 which is not what was expected when it was claimed that the calculator would allow students to concentrate on understanding the basic concepts by removing the need to perform difficult arithmetic calculations.

Coupled with these changes in teaching style, three other elements have contributed to the decline in standards. For political reasons, not least to keep the unemployment figures low, it became government policy to increase the number of students in higher education. These rose from about 6% in the early sixties to almost 40% now, and this is as it should be. However, it has to be recognised that amongst this larger group there will be individuals who are less able that those in the very selective 6% group. It is unfortunate that the secondary education of these less able students occurred when there was the shift in emphasis to time-consuming activities such as investigations and data collection at the expense of the consolidation of technical fluency. Secondly, because of the increase in numbers of students in higher education, there has been a drawing off of able secondary school teachers from that sector. Thirdly, many students now enter higher education from further education with more vocationally inclined qualifications than was traditionally the case. It has been widely recognised that the continuous assessment element in their courses has led to a variability in standards from college to college and that students entering higher education have experienced problems particularly with mathematics.

We are now faced with increasing numbers entering higher education from a school background that has de-emphasised the acquisition of basic skills and where teaching within the schools has been undertaken by less able teachers, together with students from a background in further education where the assessment style casts doubt on the knowledge and skills obtained.

Universities, under pressure to increase student numbers, are having to accept students with different, some would say worse, qualifications. Many of these students arrive without basic skills. They know this and lack the confidence to improve. Even when these new students are able, their interests and motivations are different. We can no longer assume that students will learn on their own.

There have been reports published by bodies like the London Mathematical Society and the Engineering Institutes, which highlight the problems described above, but in general, universities are not willing to expose themselves by admitting how poor their incoming students are. However, the number of conferences held in the last few years on basic skills is evidence that the problem is recognised, at least by those at the chalk face.

It has been argued that with the advent of computer algebra systems and the widespread use of statistical packages there is less need for students to have basic skills. Neither computer algebras nor statistical packages are expert systems. Before data can be entered into either, and again when the output is analysed, the user needs an understanding of basic mathematical ideas. It is very much a case of garbage in garbage out.

A list of basic skills needs to be identified. At the very least it should contain numeracy including ratio, basic algebra and graphicacy. The list will need to be extended for those studying subjects which need more mathematics, for example engineering and science students will need geometry, trigonometry and more than the basic algebra. Unless use of the basic skills in these areas becomes automatic, students will not progress satisfactorily. It is not enough to be able to do every step in solving a linear equation by slowly and painfully isolating a single x since if this process is not automatic the students will never be able to do more complicated mathematical manipulations. Speed needs to be developed in basic operations; speed is not a measure of ability but of experience and practice. In short, the student needs to become fluent at the basic skills.

Once the list of such skills has been identified then the ability level of each student has to be assessed. There are several diagnostic computer based systems available. In the past I have used a paper-based system, a computer based system TASMAT written in Authorware, and when dealing with small groups of students, I have interviewed individuals whom I thought might be at risk. The advantage of the latter, which I accept cannot be used when numbers are large, is that an immediate rapport is established, and I have found that the repair work has been more successful. Other computer-based diagnostic testing systems are being used routinely in the United Kingdom. Appleby and Sabour have used Diagnosys. Greenhow and McCabe have used Question Mark for several years and Hibberd has developed one also using Authorware.

Then comes the repair work which we choose to call levelling. Evidence suggests that not being able to do basic mathematics is more a matter of attitude than ability. Gaining confidence is an essential step for most students. We need to build up their skills in a non-threatening, supportive environment. We also need to recognise that whilst formal mathematics is presented deductively, and we progress from the abstract to the concrete, human learning in mathematics, for most people, is the reverse. People learn from examples. They recognise patterns. The true understanding of concepts often comes late in the process of learning. If this is the case then we need to find a way in which students can do as many problems on a topic as they need in a supportive environment and, given the strains on higher education budgets, at as little cost to the institutions as possible.

With the number of students and the different levels of skills and knowledge, it is not unreasonable to propose that a well-constructed supportive CAL package could provide the examples and exercises and monitoring needed. Before I proceed to describe our system that has been used for the past 8 years, it will be useful to outline some of the lessons learned about the organisation the levelling process. Circumstances will probably not allow you to follow all the guidelines suggested, since few of us have control over our working environment.

Establish a good rapport with the students. Try to arrange that the each student sees the same informed and concerned member of staff at every meeting. If the student feels that someone cares, then he is much more likely to buckle to and try to get to grips with his difficulties.

Be explicit about what the student is expected to do. Estimate how long you think the programme will take and set deadlines. In most cases the students other courses will be continuing and he will have to find the time for the levelling. In an ideal world the university would be prepared to recognise the problem and the necessary sessions could be built into his programme of study.

Be prepared to accept failures. Not all students want to be helped.

Ask the student at the end how the help could have been improved.

The courseware that I have used has two levels; CORECALMAT at the standard of O level and CALMAT which is at the interface between school and university. This latter is used widely in schools, colleges and universities both in the United Kingdom and abroad. The former was developed in response to the need to provide practice in the lower level basic skills. Both groups of software have the same structure and the same style of management system. They are subdivided into programs each of the which contains interactive instructional material and tutorial exercises which contain parameters, randomly generated at run time. Each tutorial example has a complete solution which can be accessed by the user. There are assessments, in which a score of 80% or more is required before each program is judged complete. The inter-relationships between the programs in the system are displayed graphically in the form of a network, where the nodes of the network represent programs. The nodes start out beige, are coloured magenta when the program has been started and turn green when it is completed. This colour coding is reflected at the section level of each program. There is a management system which records completion data for each program, score on each assessment, usage of each program in the system and the date and time of the last use.

The software has been successfully implemented to provide levelling for students entering many different courses. Amongst those published, Pollock has used it with a Technical Education students, and Tabor with Engineers. I have used it in a Science and Engineering Access course and for levelling with biology, financial studies, mathematics, engineering and business studies students. It is well liked by students many of whom choose to buy the software for use at home.

In summary, there is a general problem of declining basic skills. In the short term this will not go away. Unless action is taken the quality of our degrees will suffer and, more importantly, because the students today are the teachers of tomorrow, the problem will get worse. CAL can provide help in mitigating these trends.

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