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*Descriptive Account*

# Are Our Students Prepared for University?

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**Abstract**

*The A-level curricula are not preparing students for a university education, concentrating more on knowledge than skills. However, because of aspects such as the modular design of A-levels, subject knowledge can also be lacking in students as they enter university education. Diagnostic tests in maths and literacy for first year bioscience undergraduates show that, although many students write well and handle numbers effectively, there is a worryingly high percentage of students with skills well below what would be expected of those opting for a biology degree programme. Such basic skills should not be taught at university. With this in mind a course was designed, piloted and evaluated to teach sixth form pupils about the skills that will be required of them at university. These included aspects such as structuring, writing, taking notes and acknowledging sources of information. Evaluation of this programme has shown it to be effective in developing an awareness of university-level skills in both school pupils and school teachers. The PreUniversity Skills programme (www.preuniversityskills.com) was launched in January 2011 and has now reached almost 200 teachers across England, with many now delivering the material to their pupils.*

**Keywords**: Transition, Mathematics, Writing, PreUniversity, Preparedness

## Introduction

A difference in expectations between university staff and student capability is evident in many areas of university teaching, and is often attributed to a lack of preparedness on the part of the students (Lowe and Cook, 2003). It is reported that there is a general lack of understanding among academic staff in the way in which school children are, or are not, prepared for university (Zeegers, 1994). For example, students are perceived as lacking skills associated with independent learning, structuring writing, and ability to tackle simple numerical problems. However, it has been argued that universities should make use of the skills undergraduates do have, rather than focus on skills they do not have, since it may well be that students never had these skills (Thwaites, 1972). University lecturers have complained about undergraduates' inability to write for decades (Covington, 1963). Whether students always lacked the mathematical skills universities expect them to have is discussed by Hoyles *et al*. (2001) in relation to mathematics degrees, where the trend appears to have been a substitution of depth for breadth in school curricula. Certainly over the last few decades there has been a noticeable decline in the academic skills with which students are entering university and this may well be attributable to changes in the emphasis of skills required for A-levels (Fee *et al.,* 2009). Hansen (1998) found that in High Schools in the US high grades were increasingly being awarded for less effort on the part of the students.

School education is no longer designed as a preparation for university (Browning and Sheffield, 2008). Teachers are teaching to syllabuses, rather than teaching skills (Julien and Barber, 2009). Much of the evidence for this decline in skills is anecdotal; for an excellent review of non-peer reviewed literature see Fee *et al*. (2009). Universities across the county are finding it necessary to lay on basic skills courses for their students when they arrive (Jones *et al*., 2011). The perceived lower standards could be linked to the higher numbers of students entering higher education, but even Russell Group universities, attracting the top students, are running

first year basic skills programmes. For those entering university from foundation courses there is believed to be a mismatch between expectations of skills and what is expected of students by lecturers (Stevenson and O'Keefe, 2011) but this may also apply to those arriving directly from school. In most current A-level biology curricula there are no extended writing or mathematical components. Basic statistics has been added to some A-level biology courses, but it does not require any knowledge of the foundation of knowledge that the statistics are based on. A student studying only science or mathematics A-levels will not have had to have constructed a sentence since they did their GCSEs, whereas university science degrees use essays in a significant number of assessments (Fee *et al*., 2009). Skills taught at school are therefore suggested as not aligned to skills valued in higher education. The exception is the recently devised extended project, offered by many exam boards. This is offering students the chance to acquire some university-relevant skills.

The skills that students are perceived to lack at university level are not only associated with learning skills, such as structuring their writing and learning independently, but also in their ability to carry out basic numerical problems. For biology undergraduates, entry requirements to university rarely include A-level mathematics. However, logarithms that are considered essential to many aspects of biology, are now not taught until A2 level (upper-sixth form), whereas they were once part of the O-level syllabus. Because of this, the type of mathematical training students get prior to university does not appear to meet the expectations of teaching staff at university, resulting in staff having unrealistic expectations of the preparedness of their incoming students (Zeegers, 1994). This mismatch has been recognised in a wide range of subjects that have a mathematical element (Cox, 2001). A similar pattern is seen in medical courses, where students without A-level mathematics were struggling (Ben-Shlomo *et al.,* 2004). These students were anxious about handling the calculations required by the course, this was even after mathematical course requirements had been simplified. Their anxiety was ill founded, since their performance at the end of the first year matched those that had A-level mathematics. The authors put this down to a fear of numbers and simple mathematical manipulations.

Curricula and assessments of A-level programmes have changed over the last few decades. Changes to A-level maths were essentially driven by market forces without any strategic vision (Hoyles *et al.,* 2001). Changes that were made were done to attract candidates, or as a reaction to 'teacher pressure'. Competition between exam boards meant that changes popular with teachers and pupils spread to all exam boards (Hoyles *et al*., 2001). Teachers are under pressure to teach to examinations at the expense of skills (Julien and Barber, 2009); it has been demonstrated that transferable and generic skills are developed better in courses that are less packed with knowledge-based material (Lizzio *et al.,* 2002). However, exam boards are recognising that there is a problem and are beginning to devise ways to counteract the mismatch between skills required for A-levels and skills required for university. An example is Cambridge Assessments' Cambridge PreU Diploma. This was designed with input from university lecturers and encompasses many of the skills needed for higher education. The problem many schools have with adopting such a programme is that it involves a complete rethink of the whole sixth form programme. There should be a way of slotting skills into an existing sixth form programme which serves not only to help students prepare for university, but also assists with more university-style assessment pieces (e.g. extended projects).

The aim of the work outlined in this paper was:

- to assess the written and numerical skills students had when they arrived at university
- to study the school learning environment as a preparation for university
- to devise a way of teaching some of the skills required by universities to students while they were still at school.

## Studies of ability of first year students in writing and maths

### Methodology

A study of writing skills was carried out on eighty first year bioscience undergraduates at the University of East Anglia in 2008. During their first week at university students were given a writing exercise where they were asked to write about their experience of induction. They were given a blank sheet of paper and were not told how long they had to write for. After ten minutes they were told to stop writing. The scripts were analysed independently by three people for mistakes in spelling, grammar and punctuation. Fluidity of writing was also assessed; this could be described as sophistication of sentence structure, amount of crossed out words and phrases, and sentence structure. In the final week of the semester students were given a similar task, but were asked to write about their experiences during their first semester. Scripts were analysed as before by the same people. Between these two assessments students were given writing exercises such as the Science Log (Jones, 2008), lectures on essay writing, and writing practice through standard assessments such as essays and laboratory reports where feedback was given on writing style as well as content. At the end of the second semester students were asked about the effect of this teaching on their writing; students were asked to tick any of seven statements that applied to them. In addition, they were asked whether there was more emphasis on writing skills than they had expected. They were also asked to rank the importance of writing skills and mathematics skills to science graduates relative to a knowledge of biology, a general wider knowledge, and presentation skills. Fifty five students completed the questionnaires.

Bioscience students at UEA have been given a diagnostic maths test since 2007 during week one of the first semester. The results of this fed into a maths course designed to tutor students in basic maths skills required for a bioscience degree (Jones, 2010). The test was divided into four sections of increasing difficulty. Results have been matched against GCSE grades and correlated (correlation coefficient 0.665, $df = 72$, $p < 0.001$,) against achievement in subsequent maths teaching (Baldock, 2011). The test provides a much more sensitive separation of students according to their abilities in maths relevant to a science education. The test was turned into an electronic test by Password (www.englishlanguagetesting.org). Section A of the diagnostic maths test was given to a class of thirty year-six school children (aged 10–11 years) at a state junior school.

Some small-scale studies were carried out in state high schools in East Anglia. Questionnaires were given to teachers at a selection of secondary schools, asking how they rated the mathematical and numerical abilities of their pupils, and how they rated the national curriculum in delivering students who could tackle the mathematical requirements of a science degree. Twenty three questionnaires were completed, mostly by groups of teachers, a few from individual teachers. Questions all required teachers to score their answers on a five-point scale from ‘very poor’ to ‘very good’.

## Results

From the literacy assessments carried out when students first arrived at university, 27% of students were assessed to have poor writing skills (Table 1).

***Table 1*** *Assessment of student writing skills before and after a programme of writing exercises*

| Score | Initial assessment (n = 95) | Final assessment (n = 76) |
|---|---|---|
| A (good) | 25 | 40 |
| B (fair) | 47 | 23 |
| C (poor) | 23 | 13 |

This was reduced to 15% of students following one semester of writing practice and instruction. The percentage of students showing good writing skills rose from 29% to 47%. In response to the statements students had to select about the effect the writing exercises had on their writing skills, it was encouraging that only seven students believed that the writing instruction and practice made no difference to their writing (Figure 1).

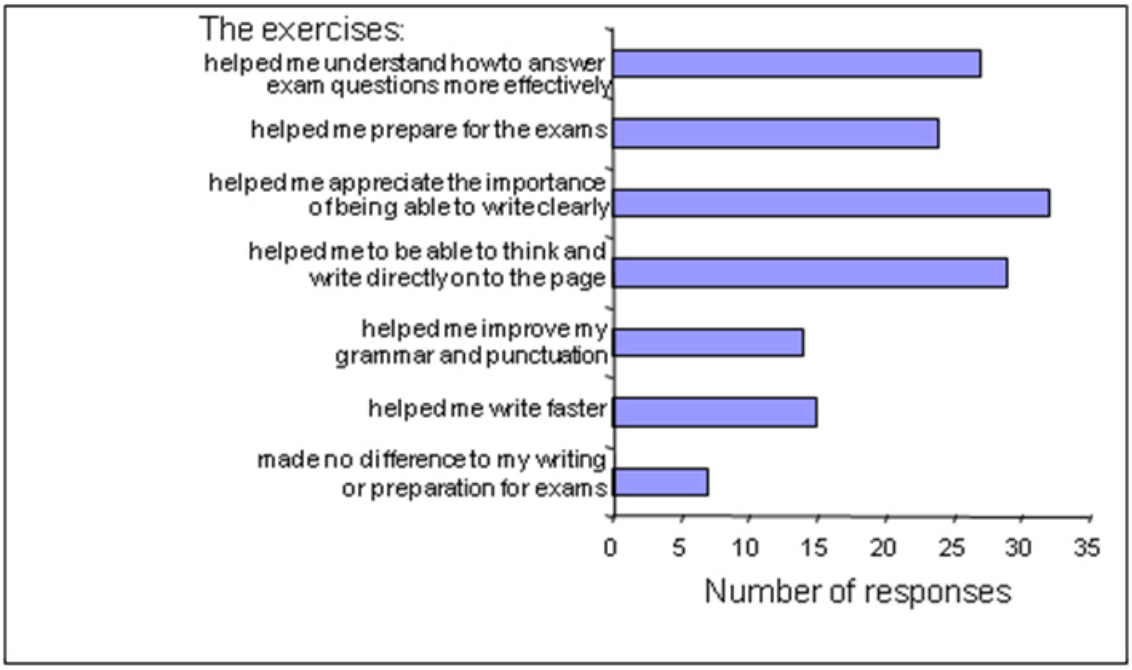


***Figure 1*** *Responses of first year bioscience undergraduates to a series of statements relating to their experience with exercises designed to help improve their writing skills. Students were able to select any responses which applied to them*

Most responses were to the statement that the teaching helped them appreciate the importance of being able to write clearly. This is fundamentally important because an appreciation of its importance should motivate students to continue working to improve their writing. In the same study students were asked if there was more of less emphasis on writing at university than they had expected. Out of 55 responses, 31 said there was more emphasis, one said there was less than they had expected, and 23 said it was about what they had expected. When combining assessment of the relative importance of numerical skills and writing skills, students assessed the importance of writing far higher than the importance of mathematics (Figure 2).

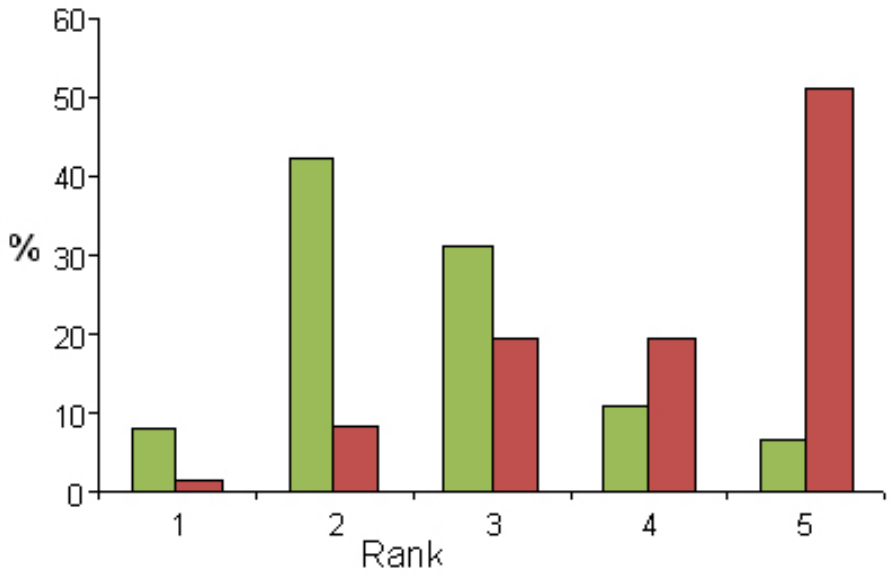


***Figure 2*** *The percentage of first year biosciences students who ranked writing skills (green) and mathematical skills (red), relative to a knowledge of biology, general knowledge and presentation skills, when considering their importance to future employers (ranking was 1 to 5, where 1=most important)*

An analysis of the diagnostic maths test relative to GCSE grades is detailed in (Baldock, 2011). Section A of the diagnostic maths test comprised very simple numerical questions. A small, but striking percentage of university undergraduates were found to struggle with basic numerical problems (Table 2).

***Table 2*** *Number of undergraduates and year six school children getting questions wrong from Section A of a university diagnostic maths test*

| | **Number of individuals getting the answer wrong** | |
|---|---|---|
| **Questions** | **Undergraduates (n=244)** | **School children (n=30)** |
| Calculate 8 x 13 | 9 | 0 |
| Express 0.5 as a fraction | 3 | 0 |
| Express 24/100 as a percentage | 17 | 0 |
| Calculate 50% of 40 | 1 | 0 |
| Rearrange *y=mx* to allow you to calculate *m* | 26 | 26 |
| If a square has sides of 2cm, what is its area? | 17 | 0 |

Year six school children did not encounter the same problems and could complete all questions in the first section of the test without error, with the exception of the algebraic question. In school staff responses to questionnaires about maths ability, most responded that preparation in maths was only ‘adequate’ or ‘poor’. It is noteworthy that this was the generalised opinion of science teachers who were teaching students who were preparing to go to university.

## Development of a preUniversity skills course

### Methodology

In 2009 a team were gathered together comprising lecturers from Biology and Literature, a PGCE secondary science tutor, a specialist in transitional skills and a learning enhancement tutor (all from UEA) and a school teacher from Wymondham High School in Norfolk. A project was funded by Excellence East to devise and pilot a short course for sixth form pupils which would help them appreciate skills that would be required at university. The first pilot was run at Wymondham High School with Year 12 pupils, where it was evaluated by two school teachers and by the pupils themselves. A second pilot was run at the City of Norwich School with a mixture of year 12 and year 13 pupils, and was evaluated by pupils. Both schools were large state comprehensives. The course was designed for students studying biology A-level, with a view to continuing in science at university. One key issue became apparent, that the skills the students lacked varied depending on the A-levels they studied. Lessons such as one on how to structure an essay concentrated on surface structure, whereas students studying an Arts A-level, such as English or History, did not need to be taught this skill. Students study a range of different A-levels, and this is particularly applicable to those who wish to study biology, as the subject perceived to be the least mathematical of the sciences. When the course was presented to the Norfolk Advisory Service to Schools and Teachers, the main comment was that the course needed to be relevant to all subjects.

In a survey of skills felt to be lacking in undergraduates across faculties at UEA, it was found that most skills were generic to all subjects. The emphasis varied between courses, but the skills themselves were the same. Skills such as writing concisely, acknowledging sources, taking effective notes, were all skills lecturing staff would like to see in their students, who were generally considered to be lacking. Essay structure was an issue for Arts subjects, but in the structure of the argument, rather than surface structure, which was the issue for science students. However, teaching science students how to structure an argument helps with writing the discussion sections of papers, essays and grant proposals, and in learning how to structure an argument, students have to learn about good surface structure.

Following consultation, the course was reworked as a generic skills course, to be taught to all sixth form pupils at either AS or A2. The course comprises eight lessons, some of which are completely general, and some which allow a comparison between the Arts and the Sciences. A training programme was designed to train school teachers to teach these lessons, along with detailed teaching materials. This allowed the programme to become a national course, with a web site (www.preuniversityskills.org) to support it.

### Evaluation

In the evaluation of the pilot courses students provided useful feedback and direct quotes are provided below [sic] which provide a sample of those that enabled lessons to be refined:

> *"The lessons were very good and hopefully will be useful in the future. An improvement for another time could be that more explanation could have been given as to exactly how and when this course would be useful and also at the start of the lesson about what we were to be doing. I really enjoyed the lessons."*

> *"I felt that for me some of the information was basic; such as how to structure an essay and how to layout a poster. I felt that the course was aimed at less able students than myself."*

This latter comment was one of the criticisms addressed by making the course generic to all subjects. This student was studying English A-level as well as science subjects and so

getting surface structure into an essay was something she was experienced in. Developing a sophisticated, supported argument though, was a skill highlighted by Arts lecturers as lacking in first year undergraduates, and so an appreciation of this skill was introduced into the PreUniversity skills programme.

Between January and July 2011 almost 200 teachers and others associated with schools, such as teaching advisors, have attended one of ten CPD courses to train them to teach the PreUniversity skills course. Courses have been held in locations across England. Feedback from teachers about the course has been universally positive and offers insight into what they need and value. For example, resources are very important to teachers who have limited time to prepare new lessons.

*"Good resources for us to use with students with easy to follow lessons."*

*"Able to take lessons away and use them immediately. Easy and quick to apply."*

*"Brilliant resources that we can use immediately in class."*

*"Excellent to have lessons which have been well thought out and will enhance student learning and development."*

*"Superb resources though the course is clearly geared to the needs/desires of universities it's been created with an awareness of how A level students learn."*

Teachers are aware that there is a skills gap between school and university, but find themselves restricted in being able to meet these needs, by the demands of the curriculum. Feedback from the teachers highlighted this:

*"Motivated me into thinking about skills rather than results and to put together a programme in preparation for A2."*

*"Taps into an area of student need that is long overdue."*

*"I am very aware that we send many students to uni lacking vital skills – hopefully this will resolve the number of our students who drop out in term 1."*

*"...to prepare them [students] for demands of HE – an insight into demands of HE for subject teachers at A level to take on board/develop."*

*"Addresses a real concern which had come back to college from students finishing this first year at university."*

*"I think this will be excellent to deliver to our students who will gain so much from doing this course."*

Many schools are now running the course and staff at Sherringham High School in Norfolk asked their students to evaluate the course. Their pupils were asked whether the material covered in the PreUniversity Skills course was useful:

*"Yes! Really was useful for uni because we never cover this at school before uni."*

*"Yes, it gives me a vast understanding of what would be expected of me at university level."*

*"Yes, I gained a better understanding of essays at a university standard."*

## Discussion

A-level coursework and assessments are fundamentally different to those required by universities and employers of graduates. For example, students can retake A-level exams as many times as they wish, to try and improve their grades. At university, and in employment, there would rarely be more than one chance to tackle a task. In addition, modular courses in A-level curricula, introduced to improve results (Hoyles *et al*., 2001) mean that the length of time students have to retain and revisit information is relatively short; knowledge does not need to be stored in long term memory. This can result in a lack of retained information so students start their biology degree course without knowledge of very basic concepts which were taught to them at school. Anecdotal evidence reports students regularly not knowing the difference between a prokaryotic cell and a eukaryotic cell, or the difference between haploid and diploid states. Both these are taught in A-level biology syllabuses. Being able to draw on knowledge committed to long-term memory is essential at university and in employment. In addition students get used to a culture where, if they do not try their best, they will be allowed a second chance.

The diagnostic tests of maths/numeracy and literacy, when students enter higher education, have demonstrated that students' abilities are generally not matching the expectations of their lecturers. Cox (2001) reported staff expectations of maths ability to be almost twice the performance level students could achieve. There are large numbers of students who write well and can tackle the mathematical demands of a science degree course, but there is a worryingly high percentage of students with poor writing skills and very weak numeracy skills. A-level grades do not always correlate with the results from diagnostic tests probably because A-levels are not designed to deliver the skills universities value, although students who achieve high grades tend to be students with an aptitude for learning and so may well write well and be able to handle mathematical problems.

The programme to improve writing skills in undergraduates saw an improvement in the writing ability of students with relatively little input in teaching, but 13 students in the study still had poor writing skills at the end of the study. It is clear from this that, while a few writing exercises and classes, along with practice in standard assignments, can help improve writing skills in some students, more intensive teaching would be required to get all students up to a basic standard expected of undergraduates. Students appreciated the importance of writing skills (Figures 1 and 2) and this is a really important step. It would be hoped that this appreciation meant they continued to improve throughout their degree.

Literacy levels in undergraduates are diverse and students are not always aware of their own shortcomings. Hansen (1998) found that preparedness for university was lower than in previous decades, but self confidence was higher. In higher education one key problem is how to teach basic skills without undermining the confidence of the students or having a negative effect on motivation. In a US study of students at the equivalent stage of UK A-levels, Hansen (1998) found students to be overconfident of their abilities, with 41% of students rating themselves as an 'above average' writer compared to a figure of 27% in 1966. Similarly, Robertson (2004) found students studying to be teachers, to be over estimating their basic skills in literacy and also showing poor levels of skills in carrying out basic tasks such as listing references correctly. Students were found to struggle with the language of grammar and this made it hard to communicate with them about their writing skills (Robertson *et al.,* 1998). There was little understanding of punctuation; in exercises on the use of the apostrophe 77% of students said they were confident in its uses, but in tests only 11% used it correctly (Robertson *et al*., 1998). In their study it was found that many students were unsure what was meant by grammar.

Students also seemed to be unconcerned by their poor knowledge of grammar and most in the study could not identify nouns and verbs.

In the mathematics test given to first year undergraduates as they started at university, the percentage of students getting questions in Section A wrong (Table 1), although small, was of serious concern. These are students who opted for a science degree but could not do mathematical problems that Year 6 children in junior schools could tackle. Mathematics is a subject that can instil fear in people, possibly more than any other subject studied at school. Often pupils select biology because it is a subject that is perceived to be non-mathematical. A-level syllabuses contain little or no mathematics, even population biology and enzyme kinetics are taught with no mathematical content. Universities are finding themselves having to teach mathematics at an incredibly basic level to try and help such students succeed in a science degree programme.

The huge problem universities face is not only to enable their students to carry out relatively basic mathematical calculations, but to have the confidence to tackle unfamiliar mathematical problems. There is a theory that states that if a learning behaviour has been reinforced in the past, to be displayed, the student must believe in the value of this behaviour (Bandura, 1997). It is referred to as Bandura's Social Cognitive Theory. Applied to present data (Table 1), even though the mathematical questions are extremely basic, of the type that will have been reinforced at school, unless the students can see the benefit of learning this type of mathematics, they will not be able to answer the questions. In addition, if students have a low level of confidence in their abilities, they may not even attempt a question they perceive to be hard (Eisenberg, 1991). Students may well have been overwhelmed by the new environment, and the lack of preparedness schools offer, and this can fuel the general feeling of being ill-prepared (Lowe and Cook, 2003).

Science undergraduates are expected to be able to estimate an answer, and to carry out basic calculations, such as multiplying a number by ten, without resorting to a calculator. They should be able to rearrange basic equations and simplify numerical and algebraic equations. In addition, University staff expect students to have a working knowledge of logarithms. Many students have no idea even of the concept of logarithms. This may not be a problem *per se*, but the expectation is then that universities have to teach logarithms from scratch. School teachers are probably accurate in their assessment of their pupils' preparedness for the mathematical demands of a science degree (Table 3). This acknowledgment of the situation is also reflected in teachers' comments about the need for a preUniversity skills course.

***Table 3*** *Questions to high school science teachers about post-16 pupils who they anticipate going on to study science subjects*

| | Number of responses | | | | |
|---|---|---|---|---|---|
| **Questions** | **very poor** | **poor** | **adequate** | **good** | **very good** |
| How would you rate your A-level students in their ability to tackle the maths they will experience to degree level? | 0 | 5 | 9 | 1 | 0 |
| How would you rate the A/AS science curricula in delivering pupils who will be able to handle mathematical problems at degree level? | 0 | 7 | 6 | 2 | 0 |
| How would you rate the A/AS science curricula in delivering pupils who can carry out mental arithmetic? | 0 | 5 | 8 | 1 | 0 |

In devising the preUniversity skills programme, it became clear that there were basic skills lacking in students irrespective of the degree programme they were studying. In a study of physics first year undergraduates, it was found that skills they lacked were not related to subject knowledge, but were about generic skills (White *et al.,* 1995). Similarly, in a study of biology students in high schools, skills found to be lacking were associated with sophisticated gathering of information and critical evaluation skills (Julien and Barber, 2009). The problems students faced were related to the difference between school and university. In pilots of the preUniversity skills lessons students embraced the teaching of university-level skills and teachers were very receptive to a course which helped them develop these skills in their pupils. Evaluation comments demonstrated that teachers recognised there was a need for this type of course and teachers trained in it have successfully gone on to teach the course to their pupils. When receiving the training, teachers found that, although they taught many of the skills in their schools, the level at which the skills were required at university was far higher than they had expected.

Teachers are aware of the problems faced by their pupils when they move on to university but are restricted in what they teach by the demands of the curricula. Because of this teachers have been extremely receptive to a short preUniversity skills programme of prepared materials which can be slotted into existing timetables. The programme has been shown to develop awareness, in both staff and pupils, of the levels of skills required at university. Skills within the preUniversity programme are taught in some subjects in schools, but it is the level at which the skills are taught and learnt that is the crucial factor. The course does not expect students to have acquired all the skills, but to develop an understanding and appreciation of the skills that are required. Basic skills teaching should not be a requirement of university education, nor should the problems associated with the transition from school to university be exclusively managed by universities (White *et al.,* 1995). The overall aim of the preUniversity skills course is to develop awareness of the demands of university education in school children before they arrive at university, and the evaluation comments suggest that the course is meeting this aim.

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## References


Baldock, A. (2011) Assessing the numeracy and mathematical knowledge of students entering foundation programmes, a new approach. *Inform*, **7**, 15–16

Bandura, A. (1997) *Self-efficacy: The exercise of control*. Freeman W.H. and Co, New York

Ben-Shlomo, Y., Fallon, U., Sterne, J. and Brookes, S. (2004) Do medical students with A-level mathematics have a better understanding of the principles behind evidence-based medicine? *Medical Teacher*, **26**, 731–733

Browning, C. and Sheffield, S.L. (2008) Practice makes perfect? University students' response to a first year transition course. *Collected Essays on Learning and Teaching,* **1**, 22–27

Covington, R.N. (1963) The development of the Vanderbilt legal writing programme. *Journal of Legal Education,* **16**, 342

Cox, W. (2001) On the expectations of the mathematical knowledge of first-year undergraduates. *International Journal of Mathematics Education Science and Technology*, **32**, 847–861

Eisenberg, T. (1991) On building self-confidence in mathematics. *Teaching mathematics and its applications*, **10**, 154–158

Fee, H., Greenan, K. and Wall, A. (2009) An investigation into secondary school exit standards: Implications for university lecturers. *International Journal of Management Education, **8**, 43–52*

Hansen, E.J. (1998) Essential demographics of today's college students. *AAHE Bulletin*, **51**, 3–5

Hoyles, C., Newman, K. and Noss, R. (2001) Changing patterns of transition from school to university mathematics*. International Journal of Mathematics Education Science and Technology*, **32**, 829–845

Jones, H.L. (2008) Developing students' writing skills: the Science Log. *Centre for Bioscience Bulletin* **25**, 2

Jones, H.L. (2010) Teaching basic maths to bioscience students at UEA. *Bioscience Learning and Teaching Case Study*. www.bioscience.heacademy.ac.uk/ftp/casestudies/jones.pdf) (accessed 3 October 2011)

Jones, E., Laugharne, J. and Redding, P.M. (2011) *The development of academic skills: an investigation into the mechanisms of integration within and external to the curriculum of first-year undergraduates*. Thesis submitted to the Cardiff School of Management University of Wales Institute Cardiff, Western Avenue

Julien, H. and Barber, S. (2009) How high-school students find and evaluate scientific information: A basis for information literacy skills development. *Library and Information Science Research,* **31**, 12–17

Lizzio, A. Wilson, K. and Simons, R. (2002) University students' perceptions of the learning environment and academic outcomes: implications for theory and practice. *Studies in Higher Education,* **27**, 27–52

Lowe, H. and Cook, A. (2003) Mind the gap: are students prepared for higher education? *Journal of Further and Higher Education,* **27**, 53–76

Robertson, C., Keating, I. and Cooper, B. (1998) 'I don't seem to have done very much work on English Grammer (sic) at all'. A study of the written English skills of first year undergraduate student: their perceptions of the reality. *Journal of Further and Higher Education,* **22**, 5–14

Roberston, I.J. (2004) Assessing the quality of undergraduate education students' writing about learning and teaching science. *International Journal of Science Education*, **26**, 1131–1149

Stevenson, C. and O'Keefe, J. (2011) Developing students' research and inquiry skills from year one: a research informed teaching project from the University of Sunderland. *Innovative Practice in Higher Education*, **1**, 1–26

Thwaites, B. (1972) *SMP: The first ten years*. Cambridge University Press, London

White, R., Gunstone, R., Elterman, E., Macdonald, I., McKittrick, B., Mills, D. and Mulhall, P. (1995) Students' perceptions of teaching and learning in first-year university physics. *Research in Science Education*, **25**, 65–478

Zeegers, P. (1994) First year university science – revisted. *Research in Science Education,* **24**, 382–383