

*Research Article***Students' Perceptions of Skills Acquisition in the Undergraduate Bioscience Curriculum**

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Key or transferable skills have received increasing attention in undergraduate curricula over recent years. In the Biosciences, most of these skills had been incorporated as an implicit component of the degree programmes. Initial surveys of graduating bioscience students from the University of Leicester indicated that about half were not aware of having received skills training via this route. Following the introduction of specific skills modules into the first and, subsequently, second years, and explicit reference to key skills in all module specifications, there was a marked increase in students' awareness of skills training and in their perceptions of the quality of training received. Students' confidence in their ability to perform skills-related tasks, excepting numeracy, increased between entry and graduation. This increased confidence was also apparent for skills such as group working for which there was no explicit training provided. There was also a trend of increased overall confidence shown by graduates who had taken the skills modules, though this was not significant for any individual skill. Making generic skills acquisition an explicit part of the curriculum clearly raised awareness of the skills that were taught formally and also those that remained implicit.

Keywords: key skills, students' perceptions, bioscience curriculum, teaching quality

Introduction

In recent years there has been an increasing emphasis in Higher Education on the development of students' key skills, particularly in relation to employability, and following the publication of the Dearing Report *Higher Education in the Learning Society* (1997) and the Quality Assurance Agency's guidelines for programme specifications (QAA, 2000). In secondary education there has also been a focus on generic skills training, for example through Curriculum 2000. Curriculum 2000 was introduced in the UK in September 2000 to establish a revision of the range of qualifications taken by 16–19 year old students at advanced level. This incorporated the opportunity to take formal qualifications in the key skills of communication, application of number and IT. However, the key skills agenda has posed significant problems for both sectors in terms of delivery and assessment (Kemp & Seagraves, 1995; Hodgson & Spours, 2002; Tariq & Cochrane, 2003).

The key skills are often divided into six main themes (Murphy, 2001, Tariq & Cochrane, 2003):

- Communication
- Application of Number
- Information Technology
- Problem Solving
- Working with Others
- Improving Own Learning & Performance.

Unlike many subject areas in higher education, the nature of the biosciences means that many aspects of these skills have always been an implicit, if not an explicit part of the undergraduate programme. To take the example of a typical undergraduate practical class, students will often be working in pairs or larger groups and will frequently engage in problem-solving activities, which may range from experimental design to trying to find out why the experiment has not worked. Information technology features widely in terms of using computers to collect and analyse data, as well as for report writing etc. Data analysis almost always involves numeracy skills, both for calculation and graphical presentation of results and for statistical evaluation of the findings. The exercise commonly culminates in the production of a report, which involves written and/or oral communication. The only aspect that perhaps does not feature automatically is that of improving learning and performance, which underpins reflective lifelong learning.

For a number of years, the University of Leicester has run an annual questionnaire survey of the entire graduating cohort, which includes questions regarding the delivery and perceived quality of skills training within the undergraduate curricula. The questions relating to skills training are phrased as:

'Please indicate in which of the following areas you were provided with assistance in developing skills and grade each one to reflect your level of satisfaction with this provision'

The list included the first five key skills, as well as additional aspects such as use of the library and foreign language skills, however, 'improving own learning and performance' was not included. Although the five key skills were embedded in the curriculum, significant proportions of the bioscience students, surveyed in 1998–99, reported not having received assistance in developing these skills. For example, approximately 40% of students ($n = 120$, surveys of 1998 & 1999 graduating cohorts combined, return rate 56%) reported not receiving training in numerical, information access or group working skills (Figure 1) and 57% of students reported not receiving training in writing skills. By contrast, 97% of the graduating students perceived training in laboratory techniques as having been delivered. Furthermore, for almost all of the skills surveyed, less than 40% of the students perceived the quality of the training received as being good or excellent (Figure 2), the highest rated provision again being laboratory techniques.

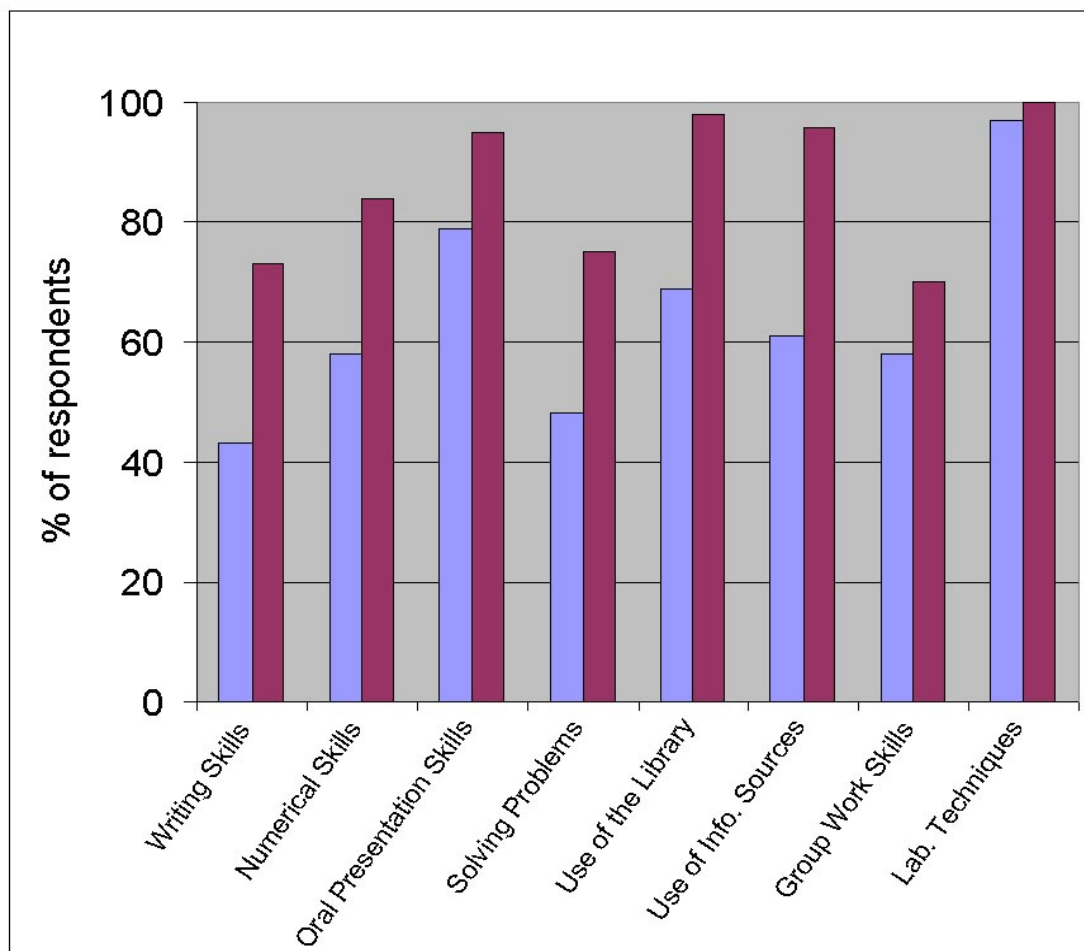


Figure 1 Proportions of graduating bioscience students reporting having received skills training. Blue columns: graduates from 1998 and 1999 ($n=120$); red columns: graduates from 2002 ($n=56$). Data taken from the University of Leicester Graduate Survey (unpublished).

In the light of these responses and the increasing emphasis on skills training from external sources along with the development of the institutional learning and teaching strategy, the School of Biological Sciences decided to embark on a vigorous skills development programme. To achieve this, the School set in place a two-component strategy to deliver key skills training and raise the level of awareness of skills development amongst the undergraduate students. The main development was the establishment of a progressive programme of explicit, discipline-based skills training. This began with two first year modules, *Study & Communication Skills* and *IT & Numeracy Skills for Biologists*, both introduced in the academic year 1999–2000. The introduction of such skills-based modules, particularly in the first year of higher education, is a strategy that has been adopted in a number of universities (Tariq, 2002). These new skills modules were followed by a second year module, *Research Skills*, which was introduced in 2002–03. In addition, the learning outcomes for each of the bioscience modules were revised, as appropriate, to include explicit reference to skills-based as well as subject-based outcomes and feedback sheets on assessed coursework were re-designed to incorporate an

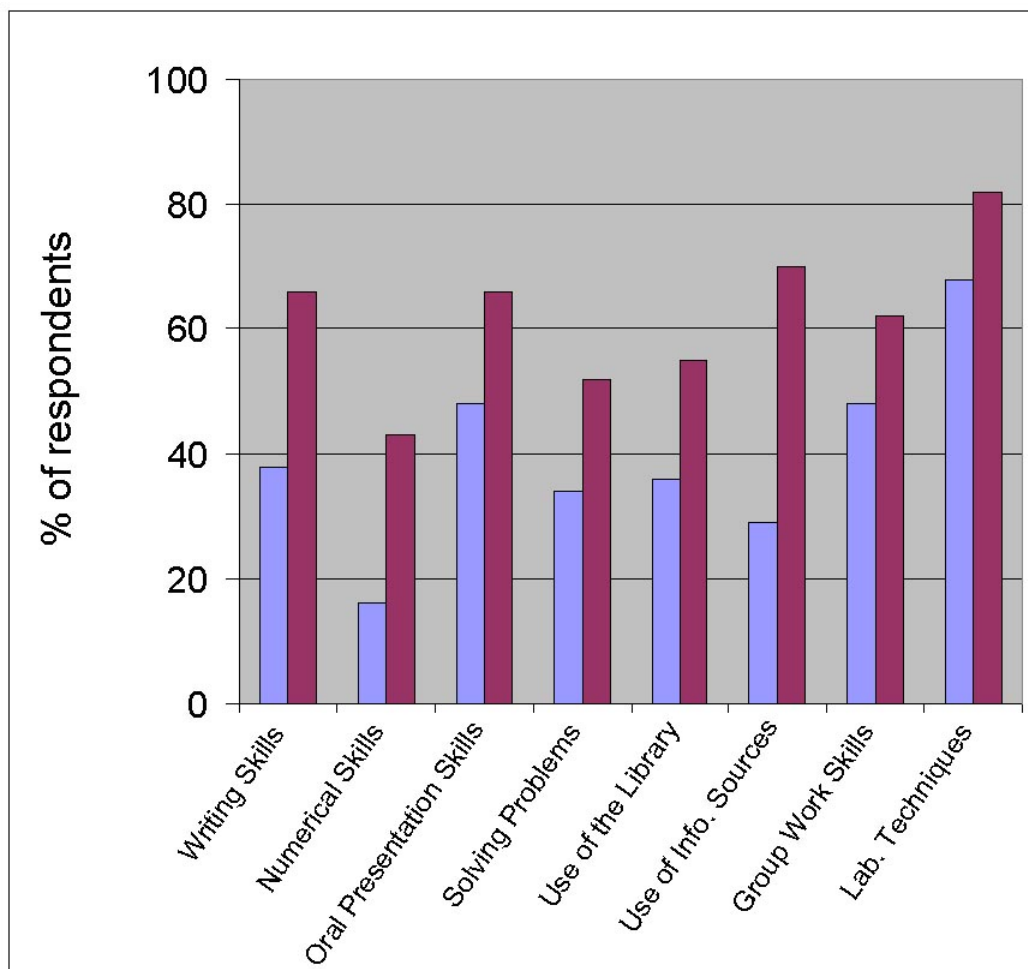


Figure 2 Proportions of graduating bioscience students reporting skills training as having been good or excellent. Blue columns: graduates from 1998 and 1999 ($n=120$); red columns: graduates from 2002 ($n=56$). Data taken from the University of Leicester Graduate Survey.

evaluation of communication skills. This period of time also spanned the introduction of Curriculum 2000 and the first intakes to the University of students experiencing this revision to the A level education.

To evaluate the impact of these changes on the students' perceptions, an annual skills perception questionnaire was run for each undergraduate year group for the period 2001–04 (see Appendix 1). This report outlines the changes made to the curriculum and discusses the changes in students' perceptions of their skills training over that period.

Methods

Changes in Skills Teaching

The initial step towards explicit skills teaching was in the first year of the undergraduate programme in Biological Sciences in 1999–2000 with the introduction of the two first year skills modules (see above). The learning outcomes for the modules, identified below, are indicative of the module content:

Study & Communication Skills module learning outcomes:

By the end of the module, students should be able to:

- Utilise different planning and organisational strategies to improve the effectiveness of their learning
- Take concise notes from lectures and written sources and use these notes to underpin their independent study
- Communicate scientific material effectively in writing and orally
- Identify strategies to support their on-going development as learners

IT & Numeracy Skills for Biologists module learning outcomes:

By the end of the module, students should be able to:

- apply a methodical approach to the solution of numerical problems in the context of biological sciences.
- demonstrate the capacity to apply mathematical, statistical and data handling techniques appropriate to the Biological Sciences degrees.
- demonstrate the capacity to access scientific literature via online bibliographic databases.
- demonstrate the acquisition of skills and attributes necessary for life-long learning, including the use of C&IT, the capacity to access a variety of resource materials and effective time management.

Given the importance of ensuring the discipline relevance of generic skills teaching (Swales, 1990; Kuo, 1993; Durkin & Main, 2002), both these modules were designed to be specifically relevant to Biological Sciences students rather than being generic skills modules. Design and delivery of the IT & Numeracy module was effected by academic staff from within the School. The Study Skills module was developed and delivered in collaboration with staff from the University's Teaching and Learning Unit. A further element to the emphasis on skills training was an addition, also in 1999–2000, made to the coursework feedback sheets that students receive on all submitted items of coursework, whereby the marker is required to provide specific feedback on aspects of the quality of the presentation as well as the scientific content.

Subsequently, the explicit skills training was developed, to provide progression and reinforcement, by the introduction in 2002–03 of a core second year module, *Research Skills*. This module included additional development of skills in data handling and analysis, scientific presentation and information retrieval, as indicated below.

***Research Skills* module learning outcomes:**

By the end of the module, students should be able to:

- Search for information effectively using on-line data bases

- Design an experiment including selection of appropriate sampling techniques and estimation of the numbers of replicates required
- Appreciate the ethical implications and associated legal requirements of different types of biological research
- Handle and analyse different types of data effectively using appropriate statistical techniques
- Interpret and present experimental data in writing and using oral and poster presentations.

Questionnaire Evaluation

Evaluation of students' perceptions was undertaken by means of two forms of questionnaire. The first was the University's Graduate Survey, which is undertaken each summer, involving an extensive questionnaire that is sent to all graduating students. In relation to skills provision, the questionnaire addresses the actual provision of skills teaching and the graduands' perception of the quality of that teaching. The range of skills addressed were: writing, numeracy, oral presentation, problem solving, group work, laboratory techniques and use of the Library and other information sources (Figures 1 and 2). The average return rate for Biological Sciences students was 44%.

The second questionnaire was run within the School of Biological Sciences and students were asked to rank their confidence, on a four point scale (no confidence, limited, moderate and high confidence), in the ability to undertake a range of activities within all six of the key skills headings, including 'improving own learning and performance'. The survey was run for each year group at the end of each academic year from 2001–04. The first year students were also asked to complete the survey on arrival in September. This provided four years' worth of cross-sectional data and also enabled one cohort to be tracked from their entry in September 2001 through to graduation in June 2004. For the most part, the survey was distributed during core teaching sessions giving an average return rate in excess of 85%. The only year group for which this could not be done was the 2nd years, because there were no suitably timetabled core modules. Second year students were therefore asked to complete the questionnaire when returning their module selections for the coming final year. As a consequence, the return rate ranged between 35–50%. A postal survey of students who had graduated between 1994–2001 (1991–97 entry) was also undertaken, which generated 127 responses, a return rate of 22%. The n values given in the results indicate the actual number of returns, not the cohort size.

For each of the generic skills, several questions were asked which related to the formal skills teaching that had been provided (see Appendix 1 for the full questionnaire). For example, for oral presentation skills, students were asked to rate their confidence in six aspects as follows:

How confident are you in your ability to:

- a) speak clearly?
- b) match your style and content to suit the audience?

- c) organise ideas and explain them clearly?
- d) use visual aids effectively?
- e) use body language effectively?
- f) respond to questions from your audience?

To provide an overview of the perceptions for the skill as a whole, the scores for each skill were averaged.

With regard to improving learning and performance, the students were asked:

How confident are you in your ability to:

- a) appreciate the extent to which targets have been met?
- b) identify factors that have affected your performance?
- c) seek and make use of feedback and other support to help you meet your targets?
- d) identify strategies to improve your performance?
- e) select and use different ways of learning to improve your performance?
- f) evaluate the success of your overall approach

In addition to this skills-based questionnaire, each module delivered by the School is evaluated by means of an annual feedback questionnaire using a standard format, which addresses generic features of the module delivery as well as specific questions relating to each section of the module. The three skills-based modules were also evaluated using this questionnaire. In the context of this report, the two key questions relating to students' appreciation of the module as a whole and of their level of achievement were:

1. The module objectives were made clear to me
2. I feel that I have achieved the module objectives

The responses were rated on a five point scale (strongly agree, agree, neutral, disagree, strongly disagree).

Results

As described in the Introduction to this paper, the results of the combined Graduate Surveys of 1998–99 indicated that 97% of the students were aware of receiving training in laboratory techniques (Figure 1) and 79% and 69% of students reported receiving training in oral presentation skills and use of the library, respectively. It is of interest that formal training in use of the library was provided to all students, however, training in oral presentation skills was not universally provided, though students were routinely given immediate feedback on presentations they had delivered. For the remaining skills, between 40% and 60% of students reported having received training in each of them.

The Graduate Survey of 2002, which comprised the first graduating cohort to have taken the two first year skills modules, revealed a marked increase in

positive reporting of skills training for all the generic skills, with 70% or more of students reporting having received training in each of the skills. The score for Laboratory techniques did increase to 100% but also the scoring for group working skills rose from 58% to 70%. This is the only one of the skills that is still not a part of the active training programme, though development of group working experience is listed as one of the learning outcomes for a number of modules, particularly in relation to practical classes.

Students' perceptions of the quality of the training also rose markedly for all the skills between the two sets of surveys (Figure 2). In 2002, more than 50% of students reported that the training was good or excellent for all of the skills except numerical skills, which 43% of students rated as good or excellent. However, this latter still represented a large increase since the 1998–99 rating for numerical skills training was the lowest of all, at only 16%. Training in group work skills also showed an increase in perceived quality, from 48% to 62%, although no formal training was delivered.

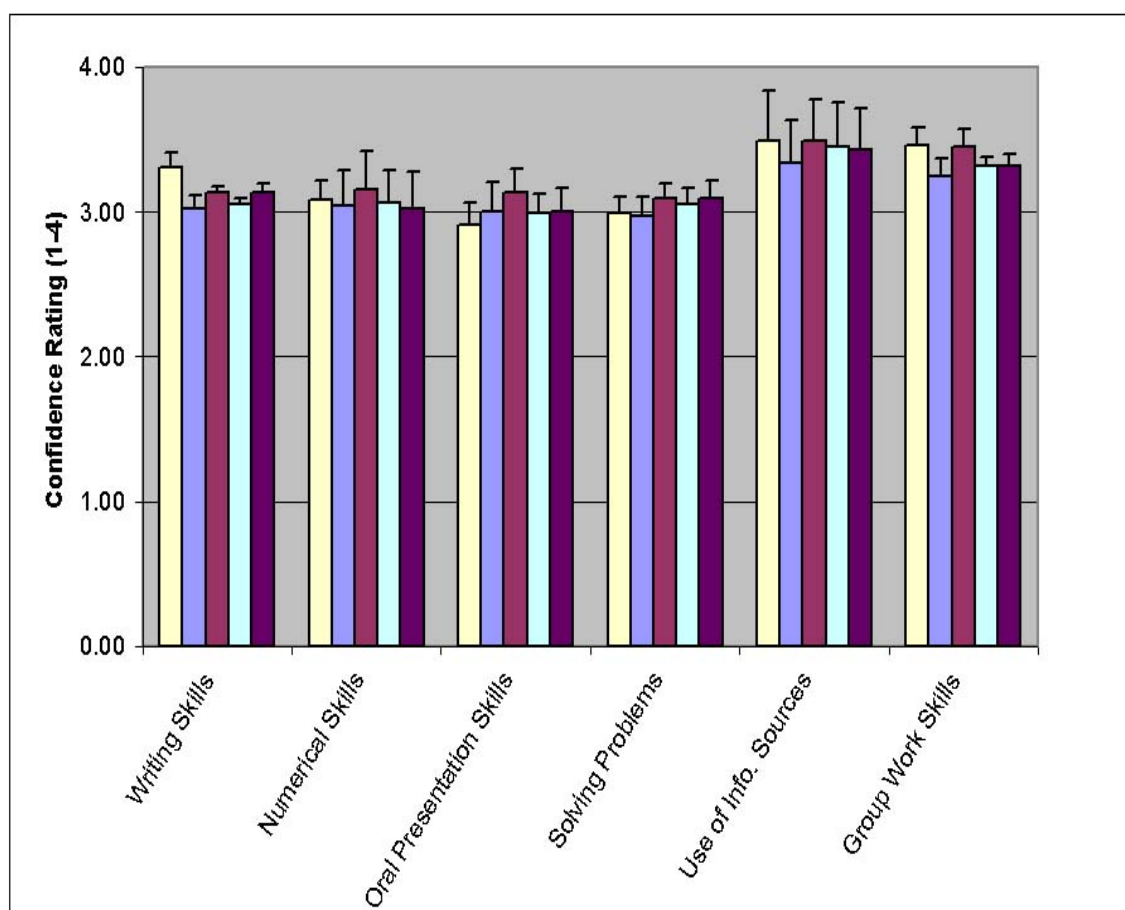


Figure 3 Cross-sectional survey of students' rating of their confidence in key skills tasks on a scale of 1–4. The students were surveyed post graduation (1994–2000 graduates) or at the end of the final year of study (2001–04). The five columns from left to right are: 1994–2000 graduates (n=127); 2001 3rd year students (1998 entry; n=86); 2002 3rd year students (1999 entry, n=86); 2003 3rd year students (2000 entry, n=78); 2004 3rd year students (2001 entry, n=98). Error bars: standard deviation.

Figure 3 shows the confidence ratings of five cross-sectional groups of students: the combined group of past graduates from 1994–2000, and students at the end of their final years in 2001 to 2004. The 2002 and 2003

graduates, who entered the School in 1999 and 2000, respectively, were the first cohorts to take the two first year skills modules and receive the targeted feedback on oral and written presentational quality via the coursework feedback sheets. The 2004 graduating cohort, in addition, took the second *Research Skills* module. Each bar indicates the mean (with standard deviation) confidence rating for the skill, with the year cohorts ranked chronologically on the x-axis.

Analysis of the data derived from the questionnaires into students' perceptions of the confidence at undertaking the different skills tasks revealed no significant changes in levels of confidence for any individual skill. However, it is noteworthy that the 2001 graduates, who had not taken any of the skills modules, reported lower confidence ratings than the other groups for five of the seven criteria. The two criteria where they did not report the lowest confidence level were oral presentation and numerical skills. By contrast, the 1994–2000 graduates, who had also not taken the skills modules but who had predominantly been in employment or further training for up to six years, showed relatively high ratings for writing, use of information sources, group work and improving their own learning.

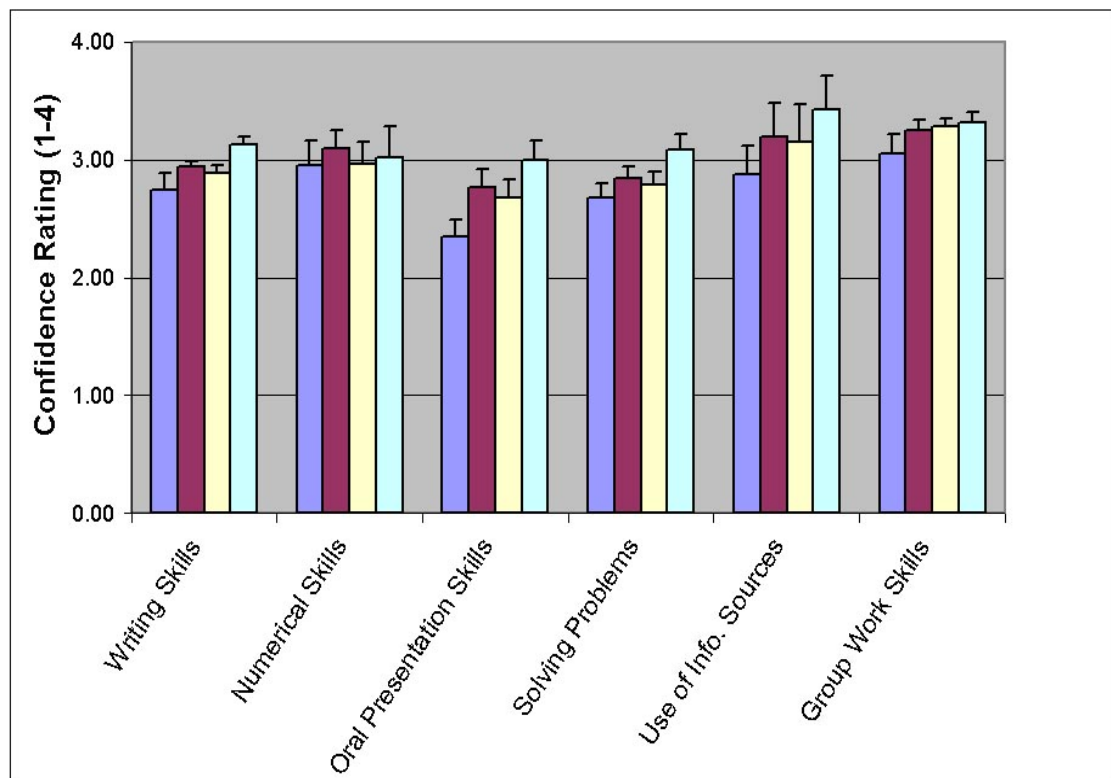


Figure 4 A longitudinal survey of students' rating of their confidence in key skills tasks on a scale of 1–4. The four columns from left to right are: start of 1st year study (September 2001, n=112); end of 1st year (May 2002, n=125); end of 2nd year (May 2003, n=33); end of 3rd year (May 2004, n=98). Error bars: standard deviation.

Comparisons of the student cohorts entering the University in 2001 and 2002 enabled investigation of any impact of the Curriculum 2000 key skills training. Although the individual differences were not significant, students entering in 2002 reported a higher self-assessment of confidence in all of the key skills

compared with those entering in 2001. However, analysis of the entry profiles revealed that, of the 2002 cohort, only 18% had actually completed one of more of the three key skills programmes at level 2 or above.

Figure 4 shows the confidence ratings of a full longitudinal survey of a cohort of students from entry in 2001 to the end of year 3 in June 2004. These students took both the 1st and 2nd year skills modules. With the exception of the numerical skills, which shows no overall change over the three years, all the skills show a small trend of increasing confidence from intake to course completion. Although these differences are not large in absolute terms, there is a significant difference between the confidence ratings for the different skills between the start of the 1st year and the end of the 3rd year ($p < 0.05$, t test).

The outcomes of the module evaluation questionnaires for all three of the skills modules indicate strongly positive ratings for both the clarity of the module objectives and students' perceptions that they had achieved those objectives. For example, in the years 2000–03 and 2003–04, over 70% of students on each of the modules reported that they agreed, or agreed strongly with both statements.

Discussion

The results presented above give an analysis of students' views on the delivery and quality of skills training, provided within the undergraduate programmes in Biological Sciences, and their levels of confidence in performing skills-related tasks. The group cohorts comprise different groupings, ranging from those who had not received any explicit skills training to those who had followed a set of three specific skills courses in the first and second years of study.

The results of the early Graduate Surveys (1998–99) show that many students were not aware of having been provided with assistance in developing the key skills when they were delivered as an implicit part of the bioscience modules. By contrast, 97% of the graduands reported having received such assistance in laboratory skills. It is noteworthy that although there were no explicitly identified training sessions in laboratory techniques, students will almost certainly have been aware of having been shown how to perform specific techniques prior to trying them for themselves and they would have received immediate feedback on their performance via the teaching demonstrators. As a consequence, the students clearly recognised the developmental processes involved. It is of interest that 79% of graduands reported having received training in oral presentation, although no such explicit training was provided. However, in almost all the sessions where students delivered oral presentations, the sessions were structured in such a way that there was almost immediate feedback given by the staff assessing the presentation, so there was a strong formative element to the assessment. This immediacy of feedback, similar to the feedback element in the practical classes, was evidently recognised by the students as incorporating a training component and has been shown to be the most effective in terms of student learning (Sassenrath *et al*, 1968; Kulik & Kulik, 1988) and is appreciated by students (DiBattista *et al*, 2004).

The ratings for the quality of delivery of the generic skills training were also low over this time period, with less than 50% of students rating the provision of training as good or excellent, compared with 68% for the training in laboratory skills. The highest rating for the quality of training for any of the generic skills over this period was accorded to oral presentation, which 48% of the students reported as having been good or excellent. This is in congruence with the observations above and again suggests that the students recognised and valued the immediacy of the feedback as a means of improving their skills.

Training in the use of the library and in the use of information sources was given formally and this was recognised by more than 60% of the students. However, during this period, this training was only given early in the 1st semester of the curriculum and the perception of quality for both aspects was low (36% and 29% reporting good or excellent, respectively). In part this may have been because the training, particularly for the use of information sources, was divorced from when the students most required those skills, which was in the 2nd and, particularly, 3rd years of study. At this time, also, the training was not delivered as part of a skills-based programme but was integrated within the 1st year academic tutorial teaching.

Introduction of the two skills modules in the 1st year programme and the inclusion of specific skills-based learning outcomes in the module specifications had a significant effect on students' perceptions at graduation. The 2002 Graduate Survey indicated marked increases in students' awareness of having been trained in all the generic skills. In aspects such as the numeracy skills, awareness of training rose from 48% to 84%. There was apparently, also, a synergistic effect in that whilst there remained no formal provision of group work training, the number of students reporting having received such training increased from 58 to 70%.

Likewise, there was a significant increase in the perception of the quality of the training being given, with at least 15% more students reporting the training for all the skills as being good or excellent compared with previously. Interestingly, the biggest rise (41%) was in relation to the use of information sources, training for which had been delivered formally to both cohorts, but which was now delivered within the setting of a skills-based module. Again, there also appeared to be a synergistic effect in that the scores also improved for group working skills, for which there was no explicit training given, and for laboratory skills, for which the same training was given to both cohorts. Part, at least, of these synergistic effects may be attributable to an overall increase in students' awareness of skills issues, through the specific skills modules and the statements of learning outcomes across the programmes as a whole. In support of this conclusion, the module evaluation questionnaires for the skills modules showed that more than 70% of the students were aware of the module outcomes and felt they had achieved those outcomes.

Students' self-assessment of their confidence at performing skills-related tasks at the point of graduation, or post graduation for the 1994–2000 cohorts

(Figure 3), showed no significant differences either between skills or between the groups, whether they had received the explicit training or not. This is in contrast with an investigation into study skills delivery that reported that all the participating students claimed to be more confident in their study skills (Durkin & Main, 2002). However, in this latter study, the survey was undertaken with immediate reference to the module, as opposed to identifying students' perceptions following a year's study that included skills modules. Furthermore, there was no comparison with the progression of students' confidence levels in the absence of specific skills training.

There were, however, trends in the results of this study, in particular the observation that the 2001 graduates, who graduated prior to the introduction of the skills modules or the additions to the module specifications and coursework feedback, reported the lowest confidence ratings of any cohort for five of the seven criteria. The two skills where they did not report the lowest confidence ratings were oral presentation and numeracy skills. As discussed above, 79% of graduands reported having received training in oral presentation before the introduction of the skills modules and this may be correlated with the formative nature of the rapid feedback normally given following oral presentations.

Confidence in numeracy skills, however, does not appear to have been altered in any way following the introduction of the skills modules, either in terms of the cross-sectional (Figure 3) or the longitudinal (Figure 4) surveys. This occurred despite the very marked increases in the proportion of graduands recognising that they had received training in numeracy and in the perceived quality of that training (Figures 1 & 2). However, these findings must be set against a background of an apparent decline in the mathematical abilities of bioscience students entering higher education (Phoenix, 1999; Tariq, 2002) and the observation that progress with numerical skills shows the lowest level of increase of any of the generic skills (Oakey *et al*, 2000).

In comparison with the students who graduated in 2001, the cohort of past graduates (1994–2000) had also not received any explicit skills training during their undergraduate careers but these showed similar or higher ratings for the generic skills with the exception of oral presentation skills (Figure 3). By the time of the survey, these graduates had spent up to six years in employment or further study/research post graduation and, therefore, these ratings probably reflect the accrual of additional experience and confidence.

It was noteworthy that the 'Use of Information Sources' tended to be the highest rated skill, even for the 1998–99 cohorts who had given relatively low ratings to the quality of delivery. This is also the skill that shows the most substantial increase between the ends of the second and third years of study. This may, therefore, reflect the extensive use the final year students have to make of data base searching techniques in undertaking the required reading for the final year modules and, in particular, the final year research project. Some support for this proposal comes from the observation that for the 2001–02 entry cohort the confidence ratings rose from 3.15 ± 0.30 (s.d.) to 3.43 ± 0.29 , these students having received all three skills modules, including

training in the use information sources in both years one and two. In comparison, for the 1999–2000 entry cohort, who only received training in their first semester of study, the ratings were almost identical, rising from 3.16 ± 0.26 to 3.49 ± 0.29 . Therefore, by the time of graduation, the reinforcement due to the exercise of the skill may well be contributing to students' confidence levels more than the effects of earlier tuition. This is not surprising, since the students will have concrete evidence of their own experience on which to base their assessment of their ability.

Overall, students' self-assessment of their ability to undertake the skills tasks increased significantly for all the skills, except numeracy, from arrival at University to graduation (Figure 4). This corresponds with the findings of other reports on skills acquisition where progress with numerical skills shows the lowest level of increase (Oakey *et al*, 2000). However, as noted above, there was no difference between the self-assessment of skills competence on graduation.

The main conclusions from this study are that many students in the School of Biological Sciences were unaware of skills training when it was embedded in the modules and not formally delivered or identified explicitly as part of the modules' learning outcomes. Where there was a clear formative element, as for laboratory techniques and oral presentations, this was identified by the students compared with the other skills. The introduction of formal skills modules, the specification of skills-based learning outcomes for the subject specific modules as well as the skills modules, and the incorporation of further feedback on presentation through the marking process markedly increased students' awareness of the provision of skills training to the extent that skills that were still only delivered implicitly (e.g. group skills) were also perceived as having been taught. Along with this increase in awareness, students' rating of the quality of the skills training provided by the School also increased significantly and, again, this incorporated skills where there was still no explicit training, and those such as laboratory skills where the training had not been changed. Students' confidence in their ability to perform skills-related tasks increased from entry to graduation but the introduction of the skills modules did not lead to an overall increase in confidence in any specific skill by the point of graduation. In part, at least, this may reflect the confidence acquired through having to utilise the skills to a greater extent in the final year of study, thereby overshadowing any effect due to the training given in the earlier years.

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