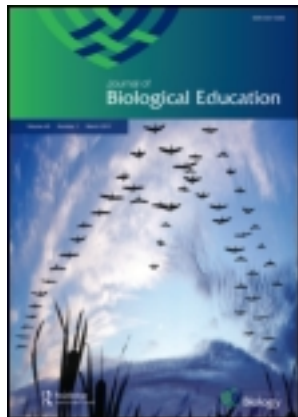


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## Group project work in biotechnology and its impact on key skills

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Group work approach to the teaching of ethical issues in biotechnology is described and its impact on the acquisition of the key skills of working together, communication, and problem solving, is evaluated. Post-16 students (A-level) were assigned to a mixed school group of six members. The *Key Skills Confidence Scale* (KSCS) was utilised to monitor students' self-confidence in each of the 47 skill items, and was applied at the beginning and end of the group project work. Statistical analyses revealed significant differences between the pre- and post-test scores, indicating a significant positive trend in students' reported self-confidence for all skill items. An attempt is made to identify the skill items that are influenced most by the group project work. Gender differences are also highlighted.

*Key words:* Group work, Biotechnology, Skills, Post-16.

### Introduction

Today there is a general consensus that students should have the opportunity to acquire the basic key skills of communication, application of number, and information technology, as well as the wider skills of working with others, problem solving, and improving their own learning (Confederation of British Industry, 1989; Dearing, 1995; Cohen, 1996; Welsh Office, 1997a; 1997b; 1998). Such skills are the key to the foundations of lifelong learning. In order to prepare students for the responsibilities and experiences of adult life, it is claimed they should be encouraged to practise these skills within a natural and realistic working environment. Consequently, training providers, such as institutions of further and higher education, have the important role of building upon the basic skills by offering courses that enable students to access other life skills that are valued by employers, such as teamwork, problem solving, and recording achievements (Department of Education and Employment, 1997).

A recognised priority of Training and Enterprise Councils and Education Business Partnerships is to assist schools to improve levels of understanding, awareness, and interest in the fields of science and technology (Department for Education and Employment, 1996; Welsh Office, 1993). To meet this goal, the biotechnology summer school was developed as an interactive residential course for A-level biological science students. The school aims to provide opportunities for local, national, and international industries to work in partnership with schools and higher education, as recommended by the Education and Training Action Group for Wales (1998).

The increasing application of biotechnology in society and the growing unease amongst the public regarding the advancement of this technology (House of Lords, 2000; Office of Science and Technology / MORI, 1999) meant that an ethics based course was felt appropriate. This provided students with an opportunity to discuss the social and bioethical implications of biotechnology on society and, also, equipped them with the key skills of communication, working with others, and problem solving.

To date there have been a limited number of investigations of students' attitudes to biotechnology (Lock and Miles, 1993; Chen and Raffan, 1999; Thomas and Thorpe, 2000) and on the influence of teaching on students' knowledge and attitudes to biotechnology (Lock *et al.*, 1995; Olsher and Dreyfus, 1999). A few have also focused on students' underpinning knowledge of key concepts in biotechnology (Lock and Miles, 1993; Chen and Raffan, 1999; Lewis *et al.*, 2000; Lewis and Wood-Robinson, 2000; Simonneaux, 2000). Generally, these research findings reveal that students have inadequate knowledge and understanding of genes, genetic engineering, genetically modified organisms, and the industrial applications of microbes. In reviewing the importance of genetically modified concepts and technology in the school curriculum, Marchant and Marchant (1999) stressed the need for tutors:

'to provide students with the skills to analyse, understand, and integrate scientific, social, economic, commercial, environmental, and ethical factors in order to reach an informed opinion'.

Yet, despite this, there is little published work in biotechnology

education in schools that set out to equip students with key skills. Most of the skills acquisition studies to date have centred on undergraduate teaching in higher education and in subjects other than biotechnology (Verran, 1992; Thomas, 1998; Foley, 1999; Houston and Lazenbatt, 1999; Clarkeburn *et al.*, 2000).

This paper reports on the impact of group project work in biotechnology on the acquisition of key skills amongst a cohort of A-level biology students.

## Research context

### Biotechnology summer school

A fuller description of the organisation of the summer school and its evaluation are provided elsewhere (Thomas *et al.*, 2000; Thomas and Griffith, 2000). In brief, the five-day residential summer school enables A-level students to be taught alongside the training of newly qualified and experienced science teachers within a university setting. The course itself accommodates up to 108 first year A-level biology students, drawn from schools throughout Wales.

### Group project work

The project work involves students from two schools working together in groups of six on a biotechnological theme. The groups discuss how one aspect of biotechnology *is of benefit to humanity*. Each group is required to present a written account (1000 words) on their topic, as well as giving an oral presentation (5 minutes) on the final evening of the course. In formulating the groups, it is ensured that each group:

- consists of students from two schools that come from different Unitary Authorities;
- has a gender mix of 50/50 (i.e. 3 males and 3 females) or 60/40 (for either gender);
- is assigned a newly qualified teacher as a mentor whose role is to support the group during both the project work and practical workshops.

### Key skills and their assessment

The key skills of working with others, communication, and problem solving (as defined at National Vocational Qualification level 3 by the Qualifications and Curriculum

Table 1 Working with others: pre- and post-test scores

Key skills item	Frequency of response (%)									
	Do not / Have not		In need of a lot of guidance		In need of some guidance		Quite confident		Totally confident	
	Pre	Post	Pre	Post	Pre	Pos	Pre	Post	Pre	Post
<b>In agreeing objectives and working arrangements, I</b>										
1. work with others as a team to plan activities***	0	0	2	0	9	0	69	41	20	59
2. offer suggestions and show I am listening to others views to agree objectives for working together**	0	0	1	0	13	2	66	48	20	50
3. identify the resources and action needed to achieve the objectives***	1	0	1	0	31	4	55	58	12	38
4. put forward suggestions for ways in which I and others could help each other***	0	0	1	0	29	2	58	52	12	46
5. listen and respond appropriately to alternative suggestions in order to agree responsibilities***	0	0	0	0	20	3	63	42	17	55
6. identify features of the working environment***	0	0	2	0	38	4	55	61	5	35
7. agree working arrangements***	0	0	0	0	13	3	71	38	16	59
<b>In working towards the agreed objectives, I</b>										
8. obtain the required resources including support from others***	0	0	0	0	19	5	68	42	13	53
9. organise my work to meet deadlines and produce work of the required quality***	0	0	3	0	22	7	52	32	23	61
10. work in a way that is safe for others and myself*	0	0	0	0	4	1	58	30	38	69
11. find ways to establish and maintain co-operative working relationships***	0	0	1	0	12	2	71	42	16	56
12. reach agreement on ways to overcome any difficulties, including conflict***	0	0	4	1	15	5	74	49	7	45
13. provide information to show how my own work is meeting expected time-scales and quality***	0	0	2	0	38	8	53	62	7	30
14. be willing to receive progress reports from others***	0	0	0	0	13	0	65	45	22	55
15. agree to make changes that are necessary to achieve objectives***	0	0	0	0	7	2	75	33	18	65
<b>In reviewing activities, I</b>										
16. reach agreement on whether or not the activity fulfilled its objectives**	0	0	0	0	19	2	68	60	13	38
17. identify factors that influenced the outcome***	0	0	0	0	27	7	59	50	14	43
18. agree what else could have been done to improve working relationships and methods***	0	0	0	0	19	6	69	50	12	44

\* p < 0.0001; \*\*p < 0.00005; \*\*\*p < 0.00001

Authority) were monitored by utilising a *Key Skills Confidence Scale* (KSCS) (Welsh Joint Examination Committee, 2000) that had been approved by the following regulatory bodies: Qualifications and Curriculum Authority (QCA); Northern Ireland Council for the Curriculum, Examinations and Assessment (CCEA); and, Qualifications Curriculum and Assessment Authority for Wales (ACCAC). This instrument consisted of 47 items. Each item was assessed on a five-point Likert scale. In this study, the Spearman-Brown Prophecy Formula reliability coefficient of this confidence scale was 0.9036. In order to measure changes of confidence over time, the same instrument was administered on a pre- and post-test basis, i.e. beginning and end of the residential course, in a similar context to the study conducted by Clarkeburn *et al.* (2000). For the same reasons as those stated by Clarkeburn *et al.* objective measures were not applied to verify increased self-confidence levels in the reported skill scores. It is believed that increased confidence will, over time, lead to skill improvement.

Out of the 96 students who completed both pre- and post-KSCS instruments, 34% ( $n = 33$ ) were male and 66% ( $n = 63$ ) were female. For each of the key skills, the KSCS mean is reported as the total confidence score and is calculated by averaging the sum of the mean item scores for each of the key skills separately.

## Results

### Working with others

The mean pre- and post-test scores for total confidence on the KSCS were 3.94 and 4.46 respectively. Students reported a highly significant increase in confidence in all 18 skill items by the end of the course (Table 1). Gender analysis of the pre-test scores revealed two significant differences. First, for item 2 males were significantly lacking confidence ( $\chi^2 = 11.213$ ,  $df = 3$ ,  $p = 0.011$ ). Twenty seven per cent ( $n = 9$ ) of males indicated that they were in need of some confidence as opposed to 6% ( $n = 4$ ) of females. For item 10 ( $\chi^2 = 6.234$ ,  $df = 2$ ,  $p = 0.044$ )

a greater percentage of males were totally confident (males: 55%,  $n = 18$ ; females: 29%,  $n = 18$ ) whereas more females were quite confident (males: 42%,  $n = 14$ ; females: 67%,  $n = 42$ ). By the end of the course there was an apparent shift in confidence for both of these skill items, particularly amongst the males, resulting in no statistical difference between the genders.

On the other hand, post-test analysis revealed significant gender differences for two skills that had previously reported no differences at the pre-test stage. Following the course, significantly more females were totally confident with regards to item 12 ( $\chi^2 = 10.731$ ,  $df = 3$ ,  $p = 0.013$ ; males: 27%,  $n = 9$ ; females: 54%,  $n = 34$ ) and item 13 ( $\chi^2 = 7.134$ ,  $df = 2$ ,  $p = 0.028$ ; males: 15%,  $n = 5$ ; females: 38%,  $n = 24$ ). These gender differences may also explain why these skills (items 12 and 13) are ranked 12 and 18 respectively (see Table 2) at the end of the course despite the perceived increase in confidence for these skills amongst the students.

Ranking of individual items (Table 2) revealed that students had greatest confidence in the same two items before and after the course; these being item 10, 'work in a way that is safe for others and myself', and item 15, 'agree to make changes that are necessary to achieve objectives'. At the end of the course, noticeable upward shift in ranking positions was reported for several items, principally:

- item 9, 'organise my work to meet deadlines and produce work of the required quality' (up from 9= at the pre-test to 7 at the post-test);
- item 4, 'put forward suggestions for ways in which I and others could help each other' (up from 15 to 11);
- item 12, 'reach agreement on ways to overcome any difficulties, including conflict' (up from 14 to 12);
- item 7, 'agree working arrangements' (up from 6 to 4).

Conversely, a marked downward shift was reported for:

- item 2, 'offer suggestions and show I am listening to others views to agree objectives for working together' (down from 5 at the pre-test to 9= at the post-test);
- item 16, 'reach agreement on whether or not the activity fulfilled its objectives' (down from 9= to 14);
- item 14, 'be willing to receive progress reports from others' (down from 3 to 5).

### Communication

The mean pre- and post-test scores for total confidence on the KSCS were 3.76 and 4.34 respectively. For all 14 items, students reported a highly significant increase in self-confidence by the end of the course (Table 3). Only one significant gender difference existed at the pre-test stage. Significantly ( $\chi^2 = 9.954$ ,  $df = 3$ ,  $p = 0.019$ ), more females reported greater confidence for item 25 (totally confident — males: 9%,  $n = 3$ ; females: 16%,  $n = 10$ ; quite confident — males: 42%,  $n = 14$ ;

**Table 2** Working with Others: means and standard deviations for the total skill score (working with others) and each individual skill item (in rank order)

Rank	Pre-test administration		Post-test administration				
	Mean	Standard deviation	Rank	Mean	Standard deviation		
	Total skill score	3.94		Total skill score	4.46	0.12	
	Skill item no.			Skill item no.			
1	10	4.33	0.56	1	10	4.68	0.49
2	15	4.10	0.49	2	15	4.62	0.53
3	14	4.08	0.59	3	1	4.59	0.49
4	1	4.06	0.61	4	7	4.56	0.56
5	2	4.04	0.61	5	14	4.55	0.50
6	7	4.02	0.54	6	11	4.54	0.54
7	11	4.01	0.57	7	9	4.53	0.63
8	5	3.97	0.61	8	5	4.52	0.56
9=	8	3.95	0.57	9=	8	4.48	0.60
9=	16	3.95	0.57	9=	2	4.48	0.54
9=	9	3.95	0.76	11	4	4.44	0.54
12	18	3.94	0.56	12	12	4.38	0.64
13	17	3.86	0.63	13	18	4.37	0.60
14	12	3.84	0.60	14=	16	4.35	0.52
15	4	3.80	0.64	14=	17	4.35	0.62
16	3	3.75	0.71	16	3	4.33	0.56
17	13	3.66	0.65	17	6	4.31	0.55
18	6	3.64	0.62	18	13	4.22	0.58

**Table 3** Communications: pre- and post-test scores

Key skills item	Frequency of response (%)									
	Do not / Have not		In need of a lot of guidance		In need of some guidance		Quite confident		Totally confident	
	Pre	Post	Pre	Post	Pre	Pos	Pre	Post	Pre	Post
<b>When having discussions, I</b>										
19. vary how and when I participate to suit my purpose and situation**	0	0	0	0	27	8	59	53	14	39
20. listen and respond sensitively, developing ideas and encouraging others to contribute***	0	0	0	0	19	2	62	48	19	50
<b>When making presentations, I</b>										
21. prepare the presentation to suit my purpose and situation***	1	0	1	1	40	10	48	48	10	41
22. match my language and style to suit the complexity of the subject, the formality of the situation and the needs of the audience***	0	1	3	1	48	11	40	54	9	34
23. structure what I say***	0	0	4	1	42	11	49	53	5	35
24. use techniques to engage the audience, including images to illustrate points***	0	0	4	2	47	12	41	37	8	49
<b>When reading and synthesising information, I</b>										
25. find and 'skim read' extended documents to identify relevant material*	0	1	1	0	28	12	57	50	14	38
26. scan and read the material to find the specific information I need**	0	0	1	0	18	5	66	46	15	49
27. use appropriate sources of reference to help me understand complex lines of reasoning and information from text and images***	0	0	0	0	30	6	62	53	8	41
28. compare accounts and recognise opinion and possible bias, and synthesise the information obtained***	0	0	1	0	30	8	63	56	6	36
<b>When writing documents, I</b>										
29. select appropriate forms for presenting information to suit my purpose***	0	0	0	0	27	3	64	52	9	45
30. select appropriate styles to suit the degree of formality required and nature of the subject***	0	0	0	0	32	5	56	51	12	44
31. organise material coherently***	0	0	2	0	30	5	57	43	11	52
32. Write, proof-read and re-draft documents clearly so that spelling, punctuation and grammar are accurate**	1	0	1	0	28	13	54	38	16	49

\* p < 0.0005; \*\*p < 0.00005; \*\*\*p < 0.00001

females: 65%, *n* = 41). Following the course, there was a marked increase in the confidence of male students with regards to this skill item (totally confident — males: 27%, *n* = 9; quite confident — males: 55%, *n* = 18) resulting in no significant difference between genders. At the pre-test stage, 46% (*n* = 15) of male students were in need of some confidence as opposed to 18% (*n* = 6) at the post-test stage. Only one gender difference was reported at the post-test stage. For item 29, female students were marginally more confident ( $\chi^2 = 5.82$ , *df* = 2, *p* = 0.054; totally confident — males: 42%, *n* = 14; females: 47%, *n* = 29; quite confident — males: 49%, *n* = 16; females: 53%, *n* = 33).

Students were highly confident in the skill of being able to 'listen and respond sensitively, developing ideas and encouraging others to contribute' (item 20) which was ranked first at both pre- and post-test stages (see Table 4). At the end of the course, noticeable upward shift in ranking positions was reported for a number of items, principally, item 31, 'organise material coherently' (up from 9 at the pre-test to 2 at the post-test), and item 24, 'use techniques to engage the audience, including images to illustrate points', (up from last to 8). Conversely, a marked

downward shift was reported for several items, principally, item 25, 'find and skim read extended documents to identify relevant material', (down from 4 at the pre-test to 12 at the post-test) and item 19, 'vary how and when I participate to suit my purpose and situation', (down from 3 to 9).

**Problem solving**

The mean pre- and post-test scores for total confidence on the KSCS were 3.85 and 4.31 respectively. For all 15 items, students reported a highly significant increase in self-confidence by the end of the course (Table 5). Only one significant gender difference existed at the pre-test stage. For item 44 ( $\chi^2 = 8.072$ , *df* = 2, *p* = 0.018), a greater percentage of male students were totally confident (males: 27%, *n* = 9; females: 9%, *n* = 6) whereas more females were quite confident (males: 48%, *n* = 16; females: 76%, *n* = 48). At the end of the course, female students reported more self-confidence in this skill (totally confident — males: 45%, *n* = 15; females: 54%, *n* = 34) resulting in no statistical difference between the genders. Several significant differences existed between the genders at the post-test stage. In

**Table 4** Communication: means and standard deviations for the total skill score (communication) and each individual skill item (in rank order)

Rank	Pre-test administration			Post-test administration			
	Mean	Standard deviation	Rank	Mean	Standard deviation	Rank	
	Total skill score	3.76	0.14	Total skill score	4.34	0.09	
	Skill item no.			Skill item no.			
1	20	4.00	0.62	1	20	4.48	0.54
2	26	3.96	0.61	2	31	4.47	0.60
3	19	3.86	0.63	3	26	4.43	0.60
4	25	3.83	0.66	4	29	4.42	0.56
5=	29	3.82	0.58	5	30	4.39	0.59
5=	32	3.82	0.74	6=	27	4.35	0.60
7	30	3.79	0.63	6=	32	4.35	0.71
8	27	3.78	0.58	8	24	4.34	0.77
9	31	3.76	0.66	9	19	4.30	0.62
10	28	3.74	0.59	10	21	4.29	0.68
11	21	3.66	0.72	11	28	4.27	0.61
12=	23	3.55	0.66	12	25	4.23	0.74
12=	22	3.55	0.71	13	23	4.21	0.68
14	24	3.53	0.71	14	22	4.18	0.74

41%,  $n = 26$ ), item 46 ( $\chi^2 = 6.202$ ,  $df = 2$ ,  $p = 0.045$ ; totally confident — males: 12%,  $n = 4$ ; females: 30%,  $n = 19$ ), and item 40 ( $\chi^2 = 6.022$ ,  $df = 2$ ,  $p = 0.049$ ; totally confident — males: 22%,  $n = 7$ ; females: 46%,  $n = 29$ ).

On ranking items (see Table 6), the same three skills occupied the top three positions at both pre- and post-test stages. These being: item 43, 'suggest and listen to the views of others to agree on the methods to use'; item 44, 'apply these methods'; and item 38, 'select the most realistic options and justify my choices'. At the end of the course, noticeable upward shift in ranking positions was reported for a number of items, principally:

order of significance, females had greater confidence for item 45 ( $\chi^2 = 7.322$ ,  $df = 2$ ,  $p = 0.026$ ; totally confident — males: 27%,  $n = 9$ ; females: 40%,  $n = 25$ ), item 39 ( $\chi^2 = 7.096$ ,  $df = 2$ ,  $p = 0.029$ ; totally confident — males: 30%,  $n = 10$ ; females:

- item 39, 'plan how to carry out my chosen options and obtain agreement from an appropriate person to go ahead' (up from 12 at the pre-test to 6= at the post-test);
- item 36, 'select and use methods for identifying different ways

**Table 5** Problem Solving: pre- and post-test scores

Key skills item	Frequency of response (%)									
	Do not / Have not		In need of a lot of guidance		In need of some guidance		Quite confident		Totally confident	
	Pre	Post	Pre	Post	Pre	Pos	Pre	Post	Pre	Post
<b>When recognising problems, I</b>										
33. recognise when they exist and check there is no immediate solution***	0	0	2	0	22	6	65	56	11	38
34. select and use different methods for exploring problems and describe the main features**	0	0	0	0	24	9	67	59	9	32
35. identify and agree with others suitable criteria for assessing whether problems have been solved*	1	0	0	0	21	7	66	61	12	32
<b>When looking at ways to solve problems, I</b>										
36. select and use methods for identifying different ways they can be tackled****	0	0	2	0	30	7	60	56	8	37
37. compare different options and justify my choices**	1	0	1	0	22	13	68	55	8	32
38. select the most realistic options and justify my choices****	0	0	0	0	16	4	72	51	12	45
39. plan how to carry out my chosen options and obtain agreement from an appropriate person to go ahead****	0	0	0	0	28	6	65	56	7	38
40. implement my plan using support and feedback from others****	0	0	0	0	21	5	72	57	7	38
41. review progress and revise my approach if necessary****	0	0	0	0	26	6	62	55	12	39
<b>When checking the outcomes, I</b>										
42. Identify methods for checking whether problems have been solved****	0	0	2	0	31	10	57	53	10	37
43. suggest and listen to the views of others to agree on the methods to use****	0	0	0	0	14	4	68	39	18	57
44. apply these methods****	0	0	0	0	18	6	67	43	15	51
45. describe the results of my checks against the chosen criteria****	0	0	0	0	27	6	66	58	7	36
46. review my approach to problem solving****	0	0	1	0	30	4	63	72	6	24
47. identify alternative methods and options and predict whether they would have been more effective****	0	0	0	0	29	5	57	59	14	36

\*  $p < 0.005$ ; \*\* $p < 0.0005$ ; \*\*\* $p < 0.00005$  \*\*\*\* $p < 0.00001$

**Table 6** Problem solving: means and standard deviations for the total skill score (problem solving) and each individual skill item (in rank order)

Rank	Pre-test administration		Post-test administration				
	Mean	Standard deviation	Rank	Mean	Standard deviation		
Total skill score		3.85	0.09	Total skill score		4.31	0.09
Skill item no.		Skill item no.					
1	43	4.03	0.57	1	43	4.53	0.58
2	44	3.98	0.58	2	44	4.45	0.61
3	38	3.97	0.53	3	38	4.41	0.57
4	35	3.89	0.65	4=	40	4.33	0.57
5	40	3.86	0.52	4=	41	4.33	0.59
6=	34	3.85	0.56	6=	33	4.31	0.59
6=	41	3.85	0.60	6=	39	4.31	0.59
6=	33	3.85	0.63	8	47	4.30	0.56
9	47	3.84	0.64	9=	45	4.29	0.58
10=	45	3.81	0.55	9=	36	4.29	0.60
10=	37	3.81	0.64	11	42	4.26	0.64
12	39	3.79	0.56	12	35	4.25	0.58
13=	46	3.74	0.58	13	34	4.22	0.60
13=	36	3.74	0.64	14=	46	4.20	0.49
13=	42	3.74	0.65	14=	37	4.20	0.64

through discussion, to develop the learning skills of: critical thinking, reading, decision-making, questioning, listening, and learning to learn.

Although it is not possible to directly compare this residential course with other group work intervention studies, there are certain features in common. For example, the Alien Squirrel exercise, a two hour work place simulation was undertaken at the University of Glasgow (Clarkeburn *et al.*, 2000) to provide an opportunity for undergraduate students to simulate decision-making at work and to support the development of the transferable skills of public speaking, decision-making, and group work. Such key skills are also central to our course except that students are given a far longer period (four days as opposed to two hours) to practise and

they can be tackled' (up from equal last to 9=);

- item 41, 'review progress and revise my approach if necessary' (up from 6= to 4);
- item 42, 'identify methods for checking whether problems have been solved' (up from equal last to 11).

Conversely, a marked downward shift was reported for several items, principally:

- item 35, 'identify and agree with others suitable criteria for assessing whether problems had been solved' (down from 4 at the pre-test to 12 at the post-test);
- item 34, 'select and use different methods for exploring problems and describe the main features' (down from 6= to 13);
- item 37, 'compare different options and justify my choices' (down from 10= to equal last).

## Discussion

In developing the biotechnology summer school we have endeavoured to ensure the incorporation of learning skills teaching alongside key skills acquisition, as advocated by Foley (1999). By setting group work on ethical issues pertaining to biotechnological developments, we have created a natural learning environment that enables students,

**Table 7** Positive shift in ranking orders (improvement)

Key skill item	Rank order adjustment		
	Pre-test rank order	Post-test rank order	Upward shift in rank order
31. organise material coherently (C)	9	2	7
24. use techniques to engage the audience including images to illustrate points (C)	14	8	6
39. plan how to carry out my chosen options and obtain agreement from an appropriate person to go ahead (PS)	12	6	6
4. put forward suggestions for ways in which I and others could help each other (WO)	15	11	4
36. select and use methods for identifying different ways they can be tackled (PS)	13=	10=	3
7. agree working arrangements (WO)	6	4	2
9. organise my work to meet deadlines and produce work of the required quality (WO)	9=	7	2
12. reach agreement on ways to overcome any difficulties, including conflict (WO)	14	12	2
27. use appropriate sources of reference to help me understand complex lines of reasoning and information from text and images (C)	8	6	2
30. select appropriate styles to suit the degree of formality required and the nature of the subject (C)	7	5	2
42. identify methods for checking whether problems have been solved (PS)	13=	11	2
1. work with others as a team to plan activities (WO)	4	3	1
6. identify features of the working environment (WO)	18	17	1
11. find ways to establish and maintain co-operative working relationships (WO)	7	6	1
21. prepare the presentation to suit my purpose and situation (C)	11	10	1
29. select appropriate forms for presenting information to suit my purpose (C)	5=	4	1
40. implement my plan using support and feedback from others (PS)	5	4	1
41. review progress and revise my approach if necessary (PS)	6=	5	1
45. describe the results of my checks against the chosen criteria (PS)	10=	9=	1
47. identify alternative methods and options and predict whether they would have been more effective (PS)	9	8	1

(WO = Working together, C = Communication, PS = Problem solving)

**Table 8** Negative shift in ranking orders (concerns/lack of opportunity)

Key skill item	Rank order adjustment		
	Pre-test rank order	Post-test rank order	Downward shift in rank order
25. find and skim read extended documents to identify relevant material (C)	4	12	8
35. identify and agree with others suitable criteria for assessing whether problems have been solved (PS)	4	12	8
34. select and use different methods for exploring problems and describe the main features (PS)	6=	13	7
19. vary how and when I participate to suit my purpose and situation (C)	3	9	6
16. reach agreement on whether or not the activity fulfilled its objectives (WO)	9=	14=	5
2. offer suggestions and show I am listening to others views to agree objectives for working together (WO)	5	9=	4
37. compare different options and justify my choices (PS)	10=	14	4
14. be willing to receive progress reports from others (WO)	3	5	2
22. match my language and style to suit the complexity of the subject, the formality of the situation and the needs of the audience (C)	12=	14	2
13. provide information to show how my own work is meeting expected time-scales and quality (WO)	17	18	1
17. identify factors that influenced the outcome (WO)	13	14	1
18. agree what else could have been done to improve working relationships and methods (WO)	12	13	1
23. structure what I say (C)	12	13	1
26. scan and read the material to find the specific information I need (C)	2	3	1
28. compare accounts and recognize opinion and possible bias, and synthesise the information obtained (C)	10	11	1
32. write, proof-read and re-draft documents clearly so that spelling, punctuation and grammar are accurate (C)	5=	6=	1
46. review my approach to problem solving (PS)	13=	14=	1

(WO = Working together, C = Communication, PS = Problem solving)

acquire these skills. In the study conducted by Clarkeburn *et al.* there was a significant positive trend in students' self-reported confidence of their own personal skills of public speaking, report making, and group work skills. However, this study, in comparing students' responses to three personal skill statements on a pre- and post-test basis, was rather limiting. In our study, we have endeavoured to use a more comprehensive instrument to measure students' self-confidence in the key skills of working together (18 skill items), communication (14 skill items), and problem solving (15 skill items).

The differences between the pre-and post-test scores clearly indicate a significant positive trend in students' reported self-confidence for all 47 skill items. On face value alone, this evidence demonstrates that the biotechnology summer school course has been successful in providing students with greater confidence in the key skills of working together, communication, and problem solving. However, a closer inspection of the results is required in order to identify more precisely those skills that have been influenced by the group project work. This can be achieved by examining the relative rank position of skills on a pre- and post-test basis and identifying any marked adjustments in skill rankings at the end of the course. This process will indicate more closely the improvements (see Table 7) that have taken place and also highlight skills that students have least confidence in or least opportunity to develop further (see Table 8). It is apparent from Table 7 that, as the week progressed, students gained more confidence in planning their group project

and were able to work more effectively as a team to deliver and present their project outcomes on time and in the form and expectation required. Increased female confidence at the post-test stage was probably attributable to the following rank order changes: item 11; item 12; item 29; item 39; item 40; and item 45. This suggests that female students were better at co-operating with group members and mentors. Although students gained confidence in all skills the relative ranking order of a certain number of skills went down (Table 8). This picture may indicate that students need more opportunity and guidance to develop these skills as they may have found them harder to acquire than others. Additionally, gender differences may have also accounted for the shift in the ranking order of a number of skills. Principally, these skills were to do with:

- working towards the agreed objectives (items 2, 13, 14, 15 – 18);
- making presentations (items 22 and 23);
- reading and synthesising information (items 25, 26, and 28);
- checking and re-drafting accounts (item 32);
- recognising and solving problems (items 34 and 35);
- reviewing outcomes (item 46).

For skill items 2, 13, and 23, male students were lacking confidence at the pre-test stage. Similarly, for item 22, female students were lacking confidence at the pre-test stage. In the case of skill items 24 and 46, female students had far greater confidence at the post-test stage.

From the results, it is evident that the group project work has been effective in raising students' self-confidence in a large number of skills. However, it has also highlighted several gender differences with respect to certain skills.

### Educational implications

As from September 2000, teaching and monitoring key skills will be a new component of post-16 curriculum (Qualifications and Curriculum Authority, 2000) and, as such, teachers will be expected to provide opportunities for students to acquire key skills in their academic studies. In science, there is now the view that the traditional approach to the teaching of factual knowledge does not prepare students for current day uncertainties in science (House of Lords, 2000). Contrastingly, the teaching of bioethics provides students with the opportunities to consider and discuss the implications of scientific developments on society and, in so doing, enables them to acquire related knowledge and key skills. In this study, it has been demonstrated that stu-



dents can acquire confidence in key skills through effective group work on biotechnological issues. In planning for group work, teachers need to ensure that the group task is:

- related to their academic studies;
- realistic and draws upon real life issues;
- achievable within the time allowed;
- closely monitored and evaluated.

In addition, teachers need to be vigilant of any gender differences with respect to certain key skills. The use of the Key Skills Confidence Scale will enable teachers to monitor students' confidence to key skills and will help to identify gender differences. Where differences do exist it is important that follow-up support is available. At the end of the day all students must acquire the same key skills.

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