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Enhancing Students' Confidence in Employability Skills through the Practice of "Recall, Adapt and Apply"

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Abstract

The ability to apply prior knowledge to new challenges is a skill that is highly valued by employers, but the confidence to achieve this does not come naturally to all students. An essential step to becoming an independent researcher requires a transition between simply following a fail-safe set of instructions to being able to adapt a known approach to solve a new problem. Practical laboratory classes provide an ideal environment for active learning, as the primary learning objective of these teaching sessions is to gain skills. However, laboratory handbooks can be presented as a series of fail-safe recipes. This aids the smooth running of practical classes but misses the opportunity to promote engagement with the underlying theory and so develop confidence in recalling approaches and adapting them to a new problem. To aid the development of employability skills, a practical laboratory series was developed for Bioscience teaching that requires on-the-spot decision-making, the recall of skills and their adaptation to new challenges. After using this approach, the proportion of student's expressing a high level of confidence with each of eight key employability skills rose by between 9 and 35% following the practical sessions, showing that the approach of recalling, adapting then applying prior knowledge and skills can increase the confidence that students have in their employability related skills. The approach was developed for use within biological sciences practical laboratories but the principles can be adapted to any discipline involving project work.

Keywords: STEM, Biosciences, employability, evidence, confidence, skills

1. Introduction

A survey of employers by the Confederation of British Industries (CBI) revealed that 23% of employers were not satisfied with problem solving skills of graduates and that 10% were not satisfied with numeracy skills (CBI, 2012). Some argue that the undergraduate curriculum is not suited to the development of employability skills and that the adoption of generic key skills into university undergraduate teaching is not best achieved in this setting (Atkins, 2011). However, others promote the development of employability skills alongside subject-specific skills (Bridgstock, 2009; Cole & Tibby, 2013; Fallows & Steven, 2000; Harvey, 2000; Knight & Yorke, 2004; Rae, 2007). Specifically, arguments are made for developing undergraduates to enable them to proactively navigate the world of work (Bridgstock, 2009). This supports a call to ensure that transformative and empowering learning is encouraged during undergraduate teaching (Harvey, 2000). Adoption of the skills agenda has led to university-wide programs to embed employability skills such as: the retrieval and handling of information; communication and presentation; planning and problem solving; and social development and interaction into undergraduate degree programs such as one developed at the University of Luton, UK (Fallows & Steven, 2000). The ability to apply knowledge to different situations is a skill that is highly valued by employers (Harvey, 2010; Saunders & Zuzel, 2010; Taylor, 1998) and for the Biosciences the ubiquitous practical laboratory class settings present opportunities to address this challenge.

The practical laboratory classes should provide an ideal environment for active learning by fulfilling the ultimate goal of developing Miller's pyramid of competencies through the act of applying theoretical learning to real laboratory experiments during practical sessions. The practical laboratory class teaching sessions should take students from the stage of "knowing", that is represented by the base of the pyramid, through the stage of "knowing how to" represented by the mid-section of the pyramid, finally reaching the ultimate goal of applying theoretical learning to a new situation, i.e., "doing", at the apex of the pyramid (Miller, 1990). The primary learning objective of these teaching sessions is to foster the skills required to develop into independent laboratory workers. However, laboratory handbooks are often presented as a series of fail-safe recipes that include detailed step-by-step instructions on assembling experiments, data collection and data analysis, dubbed the "cook-book" approach (Kloser, Brownell, Chiariello, & Fukami, 2011; Weaver, Russell, & Wink, 2008; Wood, 2009). In contrast "discovery-based" or "inquiry-based" courses have been proposed (Kloser, Brownell, Chiariello, & Fukami, 2011) to help students to develop key skills. The danger of providing fail-safe recipes is that students may not encourage engage with the theory behind the experimental approaches and so will miss important opportunities to develop skills that they can independently apply to different situations in the future. However, the "cook-book" approach is popular because students can complete practical classes with little supervision.

2. Method

A study is presented that shows how teaching can be developed to embed a need to recall prior knowledge and skills, adapt them to a new challenge and apply them within a practical class setting in the Biosciences laboratory.

A practical laboratory series within the core second-year Virology module (FHEQ Level 5 C7102) of the Biomedical Sciences BSc degree at the University of Sussex was developed to include a requirement for on-the-spot laboratory-based calculations and the presentation of complex material. Relevant employability skills from the UK based Science, Technology, Engineering and Math learning partnership (STEMnet) were considered (STEMnet, 2016) (Table 1). The teaching and learning for the practical series occurred over a six-week period through three laboratory sessions, complemented by two lecture-based presentations. An assessed report was submitted 2 weeks after the final practical class, which provides the coursework component of the module assessment. In total, this equates to 50 hours of study.

Table 1. Eight of the ten employability skills identified by STEMnet developed in this practical series (STEMnet, 2016)

Employability skill
Communication and interpersonal skills
Problem solving skills
Using your initiative and being self-motivated
Working under pressure and to deadlines
Organizational skills
Team working
Ability to learn and adapt
Numeracy

2.1 Technical Skills Survey

The technical skills required for the practical series are detailed (Table 2). Prior experience that the cohort of Biomedical Sciences BSc students encountered during their prior practical sessions within the degree program is shown, together with areas where skills are developed further within this practical series. This information formed the basis for identifying the technical skills that were best suited to use for the recall, adapt and apply approach. These skills were mapped against the skills requirements of the practical series and examples where prior knowledgeand skills could be recalled adapted and applied to a new challenge were identified.

Table 2. Technical skills survey for University of Sussex Virology (C7102) FHEQ Level 5 second year BSc module

		Prior experience		
Technical skills required	# occasions	practice	develop	new
Use of pipettes	6	√		
Use of spectrophotometer	6	√		
Use of micro centrifuge	5	√		
Use of vortex	5	√		
Use of calculation of dilutions	2		√	
Analysis of agarose gels	2		√	
Use of balances to weigh chemicals	1		√	
Preparation of agarose gels	1		√	
Loading of agarose gels	1		√	
Use of plate reader	1		√	
Photograph of agrose gel	1		√	
Estimate of sizes of DNA fragments	1		√	
Measurement of pipeting accuracy	0			√
Preparation of solutions	0			√
Use spread sheet to process data and display data	0			√
Set up of PCR reaction	0			√
Interpretation of PCR reaction	0			√
On-the-spot calculations	0			√

The instructions for the practical series were then written to embed a requirement for students to work out how to undertake several steps for themselves.

2.2 Data Processing and Data Presentation

One technical skill to be recalled, adapted and applied involved the processing and the presentation of complex numerical data. During the first practical experimental data were generated by each group (2 students) using a 96-well plate-reader instrument. The students then transferred the resulting .cvs file to the computers within the teaching laboratory and they were instructed to process the data to generate a graph showing the relationship between concentration and absorbance, the standard deviation and the regression analysis. Prior knowledge of the relevant skills originated in the teaching of data-handling the previous year. Each group inputted their data to a spreadsheet and processed it to subtract readings related to background, to determine averages from replicate datasets and to determine the standard deviation. The students then plotted a graph displaying the data, identified the line of best fit, plotted the error bars, determined the regression analysis, and the equation of the line.

The students were aware of the type of analysis required before hand and were reminded of which modules they had encountered them in previously. They had Internet access during the laboratory class and could access information as required. They were encouraged to discuss the data and data processing steps with their peers and with a member of the teaching team, which provided them with immediate feedback opportunities.

2.3 On-the-Spot Calculations

Another numerical skill to be recalled, adapted and applied involved the simple step of calculating concentrations and preparing a dilution of a sample at a standard concentration.

This skill had been taught the previous year. Each group of students prepared a unique sample during the practical and needed to determine its concentration before progressing to the next step. This ensured that all students were compelled to recall, adapt and apply their prior knowledge of the theory of the calculations to a new situation. The teaching team was available to discuss the methods chosen to undertake the calculations.

The third point for a need to recall prior knowledge, adapt it and apply it to a new situation was the on-the-spot calculations required to prepare a solution. This required accurate weighing of two chemicals, accurate measuring of the volume of a third solution and preparing the final buffer solution to a specified volume. The accuracy of the final buffer solution determined the resolution of the DNA fragments in a subsequent analysis. Again, the teaching team was available to discuss the basis behind the calculations with students.

2.4 Presentation of the Theory behind the Techniques Used

The final point required an explanation of two of the practical techniques used during the practical series. Time was provided during the practical sessions to produce one as a short, written explanation and a second in diagrammatic form. Again, an immediate feedback opportunity was available from the teaching team to support these presentations.

2.5 Evaluation Method

During the session prior to and the session after the practical, the views of the same group of students of their employability skills were evaluated by voluntary self-assessment. A mobile response system was used to collect anonymous evaluations for each skill on a Likert scale of 1-5 ($n=79$). The raw data are presented in Table 3. The data were analyzed by two approaches. In the first, the proportion of students scoring 1 and 2 were combined to represent low levels of confidence and those scoring 4 and 5 were combined to represent high confidence. The evaluations were compared before and after the practical for each question and the results represented in Figure 1. The second method combined the average scores for all of the questions before and all of the questions after the teaching sessions. This generated two overall average scores representing the situation before and after the training. A paired student's t-test was used to obtain a measure of significant of the confidence scores.

3. Results

Evaluations of the student's perceptions of their confidence in their employability related skills were undertaken before and after the practical series.

3.1 Student Confidence in Employability Skills

The driving force behind this study was an attempt to increase student's awareness of and confidence in their employability skills. The purpose of the recall, adapt, apply approach was explained to the students before the practical sessions. Data from the CBI employer's survey were presented to the students, highlighting the current perception of a skills gap in graduates (CBI, 2012). In addition, an example of a step-by-step approach to cooking (using the example of preparing glazed carrots) was presented and the skills that would be developed through this approach discussed and contrasted with the skills that could be developed by providing fewer instructions and expecting student's to recall, adapt and apply their prior knowledge to the problem. The background to the laboratory investigation was then presented, together with the points at which students would be asked to employ the recall, adapt and apply approach during the practicals.

In order to evaluate whether the active learning within the practical series impacted on the students' confidence, a survey was undertaken before and after the practicals using a mobile response devise during lecture sessions. Students were asked to rate their confidence on a scale of 1 (no confidence) to 5 (strongly confident) (Table 3). The differences proportion of students who selected a low, medium or high level of confidence for each skill was calculated and the responses before and after the practical series are shown in Figure 1. Specifically, the averages of the scores each of the skills increased after the laboratory series, and the average score for all skills combined rose significantly from 3.4 to 3.9 ($p \leq 0.05$).

Table 3. Student responses to confidence in employability skills before and after the practicals

Communication and interpersonal skills	pre	post
1=no confidence	5	1
2	13	3
3	34	17
4	22	33
5=strongly confident	5	16
total	79	70
problem solving	pre	post
1=no confidence	4	2
2	11	1
3	33	13
4	23	23
5=strongly confident	6	11
total	77	50
using your initiative and being self-motivated	pre	post
1=no confidence	8	2
2	5	1
3	26	14
4	26	19
5=strongly confident	5	6
total	70	42
working under pressure and to deadlines	pre	post
1=no confidence	8	2
2	4	4
3	24	4
4	26	28
5=strongly confident	10	18
total	72	56
organizational skills	pre	post
1=no confidence	10	0
2	10	4
3	16	8
4	24	14
5=strongly confident	12	12
total	72	58
team working	pre	post

1=no confidence	10	1
2	7	0
3	17	3
4	27	14
5=strongly confident	18	27
total	79	45
ability to learn and adapt	pre	post
1=no confidence	4	1
2	7	2
3	28	13
4	34	24
5=strongly confident	5	10
total	78	50
numeracy	pre	post
1=no confidence	10	2
2	7	3
3	17	11
4	25	21
5=strongly confident	19	9
total	78	46

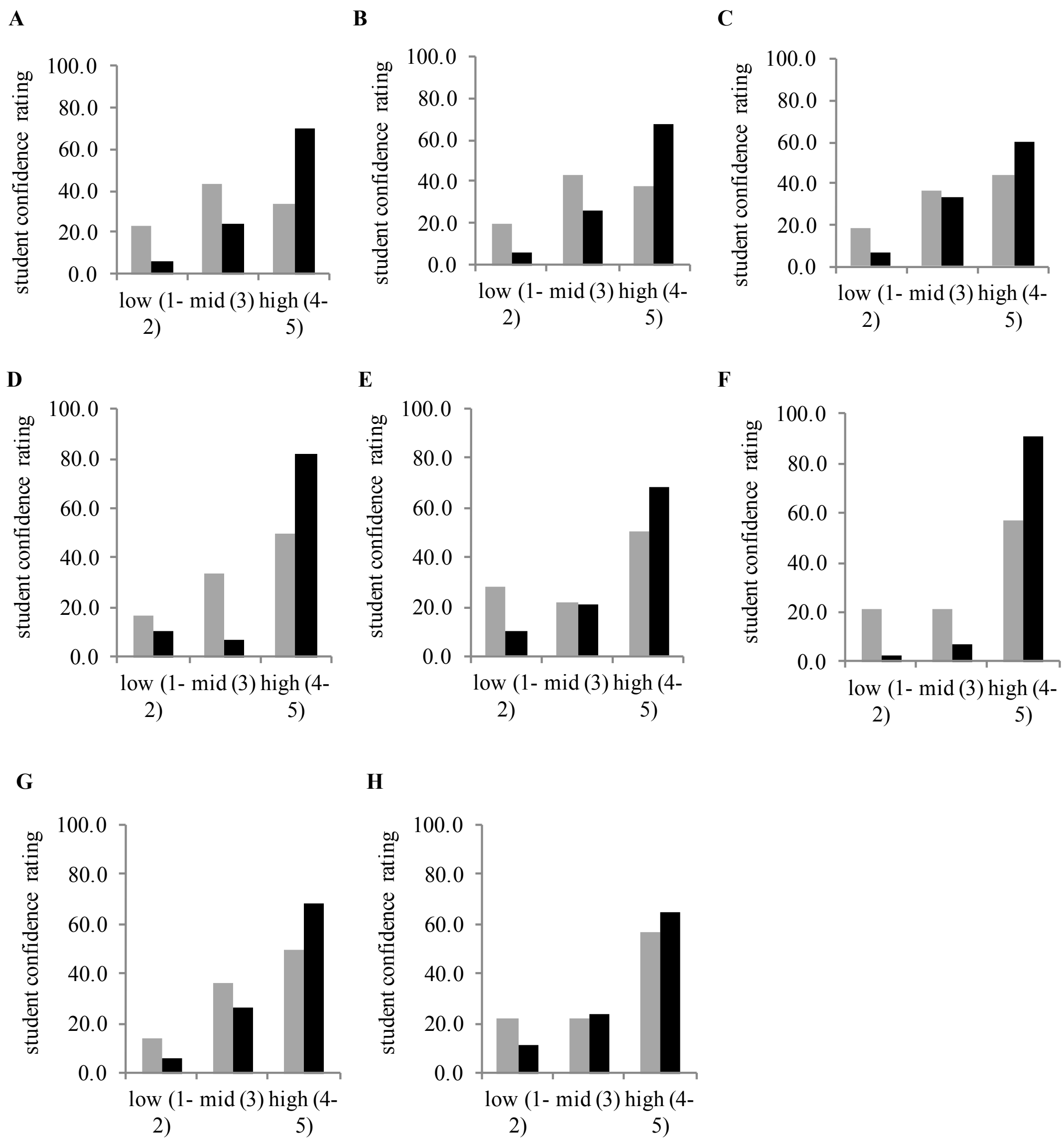

Figure 1. Impact of the practical series on the confidence of students with employability skills

Students rated their confidence with employability skills shown before and after the practical series on a scale 1-5. The proportion of students with low confidence (rated 1 or 2), medium confidence (rated 3) or high confidence (rated 4 or 5) is shown both before (grey) and after (black) undertaking the practical series. The skills relate to communication (A), problem solving (B), using initiative (C), working under pressure (D), organizational skills (E), team working (F), Ability to learn and adapt (G) and numeracy (H).

4. Discussion

The recall, adapt and apply approach described here helps to prepare students for employment. It builds in active learning to the practical classes and so also creates a stepping-stone in the student experience between the traditional "cook-book" style approach to practicals and the fully-fledged independent research projects that are considered invaluable within STEM disciplines (Kloser et al., 2011; Weaver et al., 2008; Wood, 2009). However, this requires a larger investment of time in the curriculum design to survey the prior knowledge and skills experience of the students, and so it is important to question whether it is of benefit to the students. However, once this has been undertaken, the level of supervision is similar to that required to direct a practical using the step-by-step approach.

The value of explicit rather than implicit inclusion of employability skills training has been previously supported by other studies that investigate the students' view. Examples include, explicit skills training of Bioscience students at the University of Leicester, where an increase in the confidence of students in their ability to perform skills related tasks was observed (Mills, 2005). Furthermore, a study by Corker and Holland found when the delivery skills training was explicit, a positive perception of employability skills training was identified by History students (Corker & Holland, 2015). In the "recall, adapt and apply" study, where skills training as also explicitly delivered, perception of students' confidence following the skills training was significantly increased.

The nature of the "recall, adapt and apply" practical embeds active learning by the students and engagement with the theory underlying the practical approach. In addition, and perhaps more importantly for their future careers, the students identified that their confidence in eight employability skills increased. The impact of other teaching and learning experiences during the teaching period cannot be discounted, however, at face-value the analysis supports the view that embedding active learning increased student confidence in employability skills. Therefore, the additional resource required to design embedded skills training into the curriculum is worthwhile.

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