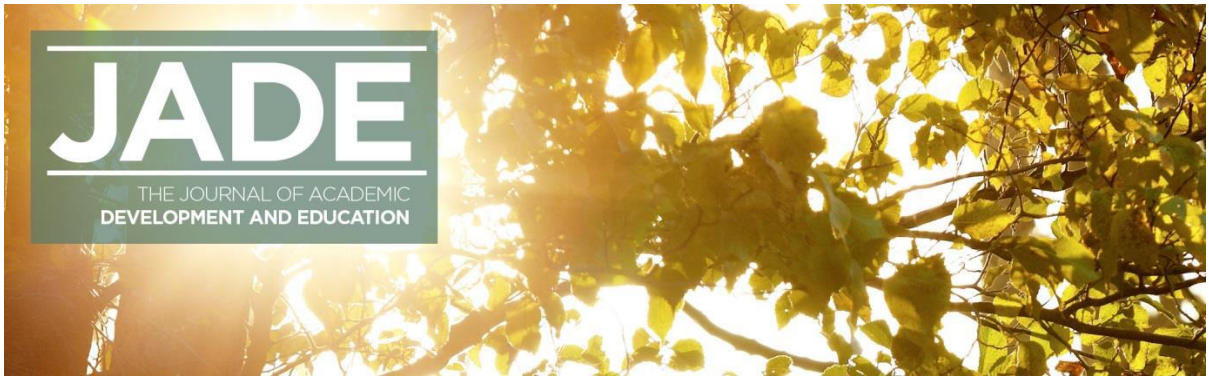

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Highlight:

Active Learning Techniques to Build Problem Solving Skills in Chemistry Students

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Active Learning Techniques to Build Problem Solving Skills in Chemistry Students

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Abstract

Through the introduction of Team-Based Learning problem classes and a 'Purple Pens' feedback intervention in which students write their own feedback on a mixed formative and summative class test we have been able to observe a significant increase in exam performance in Foundation Year students. Both Science and Health students improved their exam performance by 13% and 11% respectively and both interventions were positively received by students.

Keywords: Team-Based Learning, Purple Pens, Exam Performance, Problem Solving

Introduction

At its heart Chemistry is a problem solving subject. Traditional chemistry teaching consists of instructors working through problems in lectures, followed by students attempting similar problems by themselves, which are then handed in for marking or discussed in problem classes or tutorials. For many students the step from following an instructor tackle to them tackling it themselves is a quantum leap.

At Keele we use large group problem classes extensively in a Chemistry Foundation Year 20 credit module (FHEQ level 3) which attracts a cohort of very mixed ability and motivation. However as class sizes grew we found that the feedback about the problem classes was negative with students complaining that their questions were not getting answered during the session because of too few staff.

Therefore in 2015/16 we decided to adopt a Team-Based Learning (TBL) approach to organising these problem classes. We surmised that TBL with its focus on problem solving in a team would be an ideal way to get students to help solve each other's individual questions allowing the instructor to focus on areas where the whole cohort has misconceptions.

Adapting TBL

The methodology of TBL has been extensively reported (Sweet, 2009) however we wish to report our adaptation of TBL for our specific circumstance. We organised the teaching so that three lectures were delivered per week with a TBL session on Friday on the material presented during that week. The assessment of the module

remained the same, a summative class test (20%) which has formative feedback and a summative exam (50%) at the end of the semester together with laboratory practicals (30%).

The structure of the TBL sessions took the traditional approach with an iRAT and a tRAT testing basic background knowledge followed by application activities (Hancock *et al* 2017). The application activities took the format of modified exam level questions which had been broken up into smaller divisions with the aim of guiding the students through the question. The answers for the application activity were discussed by projecting the answers of the teams using a visualizer and asking other teams to comment on the answer and the instructor providing the correct answer. Similar levels of positive feedback from the students that we have previously reported for TBL was recorded for these sessions (Jones and Hancock, 2015).

The TBL and Purple Pens Effect

The students are divided into two distinct cohorts, Science and Health, who then move onto different faculties at the end of the foundation year. These cohorts are taught together in mixed TBL sessions in class sizes of between 50 and 65 students. Each TBL session was staffed with an instructor and a demonstrator compared to the non-TBL sessions in 2014/15 which were staffed by an instructor and three demonstrators. In total there were 10 TBL sessions across the 12 week semester.

In the first year of TBL the exam results showed a significant increase for both cohorts with average performance up by 7% for the Science cohort and 5% for the Health, see Table 1.

Table 1 - Effect of TBL and purple pens on Class Test and Exam performance

Year		Cohort Size	TBL	Purple Pens	Class test	Exam
2014/15	Science	60	-	-	58	48
	Health	31	-	-	73	56
2015/16	Science	125	YES	-	59	55
	Health	29	YES	-	62	61
2016/17	Science	85	YES	YES	55	61
	Health	35	YES	YES	63	67

In 2016/17 we decided to add in more intervention at the class test stage. In previous years it had been marked and formative feedback given alongside a summative mark by the instructor and then returned to the students. However we were concerned that many students did not engage with the feedback and therefore we adopted a feedback technique termed ‘Purple Pens’ (McGarvey and Hancock, 2017). Following the class test the instructors review the class test scripts and in a timetabled session these are returned to the students who are given a purple pen. The instructor then displays marked answers to the questions and the students correct their own script and mark it in purple and thus actually engage with the

feedback and see where the marks were awarded. The scripts are then collected in again and the marking moderated by the instructor, marks recorded and the work returned.

The average exam performance of the students continued to increase with an additional 6% increase for both the Science and Health cohorts. In this 2016/17 cohort 88% of students rated the TBL sessions good or excellent and 92% rated the Purple Pens sessions good or excellent.

We were slightly disappointed to see no increase in class test performance on the introduction of the TBL sessions in 2015/16, with a similar performance maintained in 2016/17. However, this can be explained by changes to the format of the class test to introduce some unseen questions, which was also implemented in 2015/16 whereas in 2014/15 all the questions were seen prior to the test..

It should also be noted that in 2016/17 there was a change in personnel because of a maternity leave, one of the teaching team of three was replaced by a teaching fellow new to TBL. Within one month this teaching fellow was successfully running TBL sessions prepared the previous year.

Summary

The combined TBL and purple pens improvement in exam marks has been 13% for Science cohort and 11% for Health. We believe these two simple active learning strategies have had a significant impact on student performance and have been simple to introduce and once the modest preparation has been undertaken make a very efficient and effective way to teach.

Emerging from this we have developed a rational problem solving pathway - instructor demonstration, TBL problem solving, formative individual attempt at problem solving with purple pens feedback and finally summative assessment in an exam. This pathway can be easily implemented by other subjects that have a focus on problem solving in their assessment, indeed our TBL methodology has already been adopted by Keele colleagues in Economics, Forensic Science and Chemistry, and Chemists in the UK and Europe.

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