Measuring the Effectiveness of an Open Ended Team-Based Induction Task

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Keywords: *CBL; PBL; Active Learning; Chemistry; Induction; Year One; Learning Communities*

Abstract

An evaluation of a new problem-based, open-ended induction activity for chemistry undergraduates at the University of Leicester was undertaken. Responses to the evaluation questionnaire (N=168) revealed that students appreciated the opportunity to make friends with their course mates (88.1% agreement), to discuss science with other students (76.8% agreement) and to learn how to develop a project plan (77.4% agreement). A considerably smaller number of students agreed that the activity helped them develop their time management (59.5%) or develop their problem solving (45.8%) skills. This suggests that the social benefits (e.g. learning community building) of this activity may outweigh the development of other skills and abilities.

Introduction

The University of Leicester has used Problem Based Learning (PBL) approaches in chemistry teaching since 2007 (Williams et al. 2010). This active-learning approach was adopted at Leicester to support the development of transferable skills within a disciplinary context, to facilitate the formation of strong social links at an early stage of the programme and to help students develop professional problem solving skills by introducing them to scenarios which require the application of abstract chemical principles in real-world contexts (e.g. the relevance of thermodynamics to the energy demands of a small nation).

The PBL approach was originally developed for use in medicine programmes in North America in the 1960s (Neufeld et al. 1989) but has subsequently been adopted in a wide range of disciplines including engineering (Perrenet et al. 2000; Hsieh & Knight 2008), psychology (Reynolds 1997) and chemistry (De Jesus 1995; Ram 1999).

PBL typically involves students working together in small groups on open-ended problems which are usually based on real-world scenarios. The open-ended nature of these problems often reflects the types of problems encountered by professionals in the relevant discipline area (Wood 2003). PBL problems incorporate authentic assessment practice meaning students work on real-world tasks which are assessed in the same way that professionals working on analogous problems are evaluated (Barber et al. 2015). This can support the development of a range of transferable skills including the ability to work as part of a team and the ability to communicate understanding to a range of audience types.

PBL type approaches became established in UK university chemistry teaching between around 2002-2007 (Belt et al. 2003; Summerfield et al. 2003; Belt 2009). Many of these initial implementations were more accurately described as Context Based Learning (CBL) (Gutwill-Wise 2001) as they didn't have some of the characteristics of a typical PBL problem. CBL is usually defined as any learning experience which is framed by a meaningful context (Overton 2007), PBL can be thought of as a type of CBL experience where the learning experience takes the form of an open-ended problem. In recent years the term Context and Problem Based Learning (C/PBL) has been adopted by the university chemistry teaching community in UK (Overton 2007). The C/PBL umbrella term describes any learning experience which can be described as either PBL or CBL.

Previous work has established that an effective induction is needed to effectively introduce students to the C/PBL approach (Savin-Baden & Wilkie 2006). This may be particularly important when using C/PBL in the opening stages of a degree programme as many students won't be familiar with this type of student-centred approach. Some students begin their university education with limited experience of working in teams on scientific problems, communicating their understanding verbally or managing a complex workload. Facilitating the transition from teacher-centred to student-centred teaching approaches may be a contributory factor in ensuring students get most benefit from C/PBL experiences.

A new C/PBL induction activity was recently developed for chemistry students at the University of Leicester (Williams, 2017) in order to facilitate the transition from teacher-centred to student-centred learning. The specific details of the activity have been published previously (Williams, 2017). This article will describe the findings of research conducted alongside the implementation of the activity. The primary aims of this research was to gain insight on the first reactions of students to the C/PBL approach and to identify the barriers to student learning that remain after they have completed the induction activity.

Methodology

An induction activity was developed to help introduce students to the open-ended Context and Problem Based Learning (C/PBL) methodologies used in undergraduate teaching at the University of Leicester. Specific details of the activity have been previous published (Williams, 2017) but a brief overview is provided here.

In small teams (of either 5 or 6 members), students were asked to design, develop, pilot and refine a short educational resource that could be used by other students on their programme. Teams were told that the resource had to be designed in such a way that it could be used on a twenty minute bus journey and the content must support student learning in the early stages of year one of a chemistry degree programme. Students were allowed to choose the topic of their resource (they were encouraged to select a topic relevant to the teaching in the opening half of their first term at university), the style of the resource and the manner of pilot evaluation (Williams, 2017). At the end of the activity, teams were asked to submit their activity along with a one page reflective report which justified their choice of topic and format, provided an overview of the evaluation conducted during the piloting of the resource and recommended how the resource could be improved.

This activity provided an opportunity to measure the response of students to their first experience of C/PBL. Student feedback was collected using a post-activity questionnaire based on a series of Likert-type statements and a number of free text questions. Students submitted their resources and reports in the opening five weeks of the academic year and were asked to evaluate the experience immediately after they had completed the activity. A brief overview of the learning resources that students produced was also undertaken with resources classified according to the method of presentation used.

Results and Discussion

Overview of Types of Resources Generated

A total of 34 teams (198 students) completed this activity in the first semester of the 2016-17 and 2017-18 academic years. The types of resource produced by the students were classified according to the scheme shown in table 1.

https://doi.org/10.29311/ndtps.v0i13.2680

Classification	Typical Examples
Video	Live-action, animated or screencast video. Non-interactive
Interactive web based resource	Interactive animation, question set with feedback or app.
Podcast	Audio recording with no visual content
Text-based resource	PowerPoint slides (without video/audio), revision notes and flash cards
Game	Card game

Table 1 The classification system used for the types of resources developed by students.

The breakdown of the types of resources developed by the teams is shown in Figure 1. Although there were 34 teams, 35 different resources were developed as one team developed a text based resource which was supported by a video.

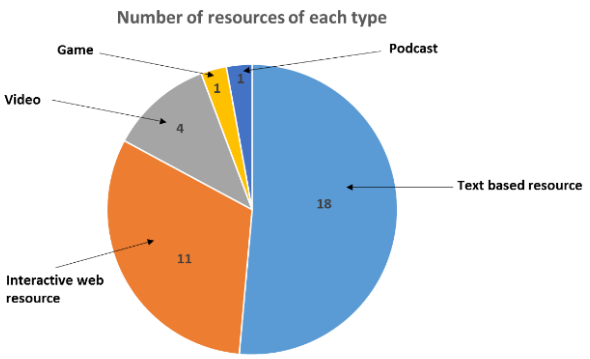

Figure 1 A breakdown of the types of resources developed in this activity. Note, the total number of resources is greater than the total number of teams as one teams produced two resources.

It is interesting to note that there was an almost equal split between text-based resources (including word processed and hand-written submissions as well as PowerPoint Presentations without video or audio elements) and digital resources (including videos, podcasts, quizzes and apps). In total there were 18 text-based resources (out of 35 resources in total) and 16 “digital” resources (including five multimedia (video or podcast) resources and 11 resources that made use of interactive web-based content). Two teams decided to make apps that could be used on mobile devices, one of which designed a working version of the app whereas the other team fully planned the app but did not build it. Of the four video resources, three were screen captures of PowerPoint presentations and one was a live-action video of a discussion between two students which included worked examples shown on a whiteboard.

The activity did not include any formal training in the use of digital tools in education (as this was not a pre-defined learning outcome of the activity). As a consequence, the format of resource that teams chose to develop was largely dependent on the level of experience and expertise of team members. As the knowledge and skills bases of the team were heterogeneous, peer-teaching played a significant role in the problem-solving process (as observed by staff facilitators).

Student Evaluation of the Activity

In order to measure the effectiveness of this activity, a short questionnaire was designed based on a Likert-type question (a five point scale was used: ‘strongly agree’, ’agree’, ‘neutral’, ‘disagree’ and ‘strongly disagree’) and two free text questions. The questionnaire asked students to evaluate their personal development as a consequence of competing this activity. Students were also asked to rate how effectively the problem gave them opportunities to engage a number of different types of learning activities. A number of text response questions were also included where students were asked to nominate the things they found the most and least useful about the problem. The questionnaire was piloted by a small number of academic staff and final year undergraduate students in order to ensure the questions were not ambiguous or leading. The questionnaire was distributed in a compulsory laboratory session to maximize the response rate. A total of 168 questionnaire responses were collected (out of 198 students in total) across the 2016-17 and 2017-18 academic years.

https://doi.org/10.29311/ndtps.v0i13.2680

Figure 2 summarises student level of agreement (defined as the sum of the percentages of students who agreed or strongly agreed) with the statement that the problem helped them with a number of different activities or processes. Two of the three categories with the strongest level of agreement reinforce the social benefits of using this problem as an icebreaker activity (Meeting New Friends (88.1%) and Discussing Science with Students (76.8%)). These responses highlight the social benefits of the activity by helping to introduce students to their team mates and getting them used to working together on academic assignments.

Two other statements which received levels of agreement/strong agreement above 50%: Developing a Project Plan (77.4%) and Reinforcing Existing Knowledge (75.6%). Only 39.9% of students agreed or strongly agreed that the activity helped them to discuss science with a facilitator. This is likely to be a reflection of the fact that the problem was dominated by peer discussion of scientific topics. Although beyond the scope of this project, further investigation may reveal whether this score was influenced by student expectations of university study (i.e. some students may believe that the role of the teacher is to be an "expert" who should "tell" students how to solve problems).

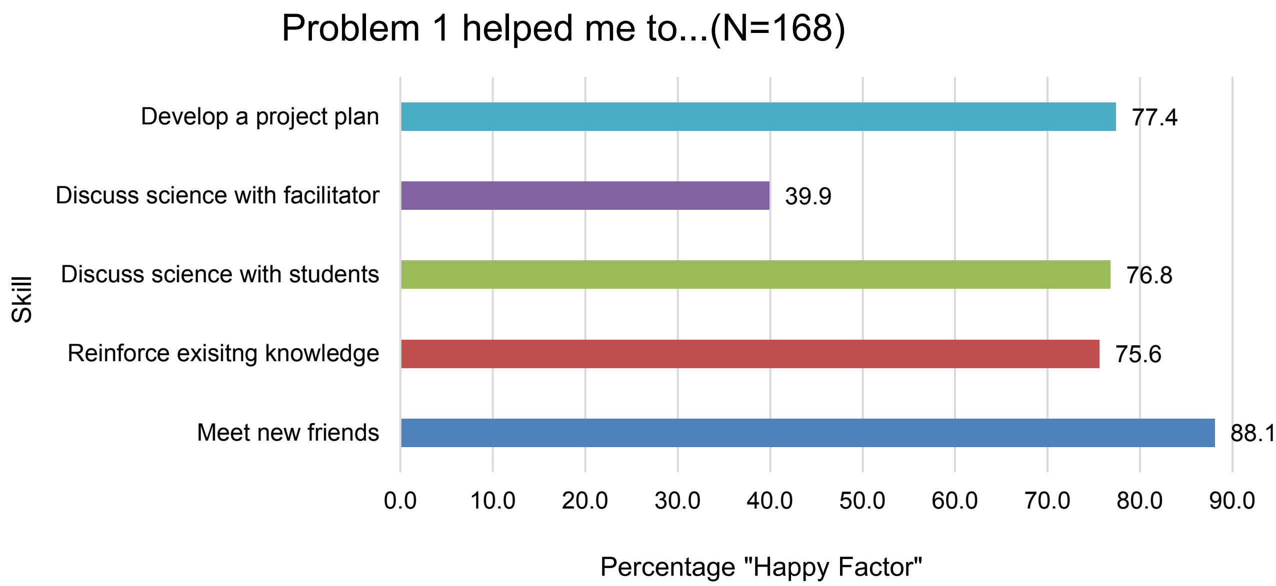

Figure 2 The percentage of respondents who agreed or strongly agreed that the problem helped them engage with the following activities or processes (N=168).

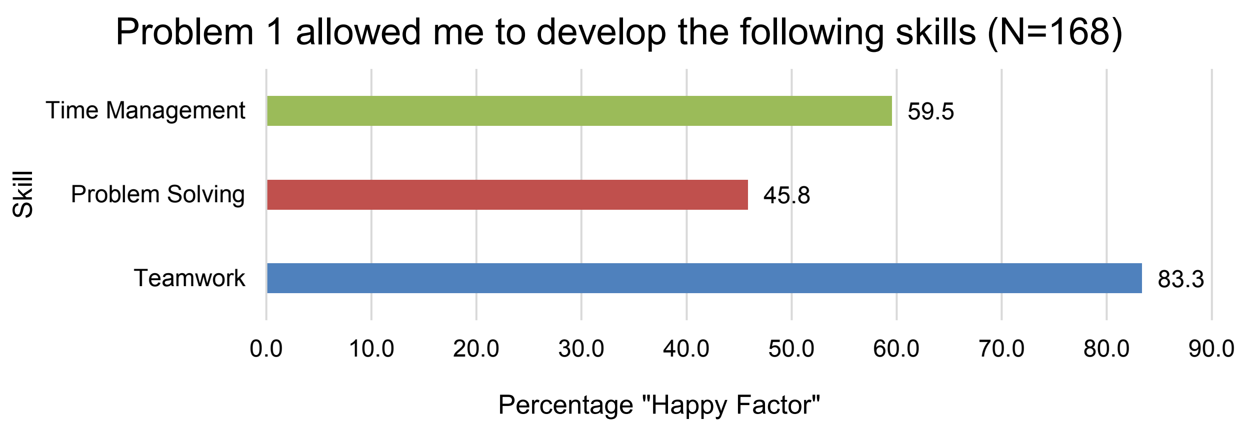

Figure 3 The skills and abilities development of students who completed the C/PBL induction activity.

https://doi.org/10.29311/ndtps.v0i13.2680

The next question asked students to rate their skills development. Of the respondents 83.3% agreed or strongly agreed that this activity had helped them learn how to work in a team and 59.5% agreed or strongly agreed that the problem helped them develop their time management skills. Only 45.8% of respondents agreed or strongly agreed that the activity helped them develop their problem solving skills. This relatively low level of agreement is possibly a reflection of the open-ended nature of the activity which students new to university may not recognise as being a “problem”. The activity was designed to give students an opportunity to apply elements of their existing knowledge to the development and evaluation of a learning resource. The activity was designed to stimulate team discussion and cooperation leading to social cohesion within the team. This is reflected in the positive student level of agreement that the problem supported teamwork, meeting new friends and discussing science with other students (figures 2 and 3).

Students in the 2016-17 academic year were also asked to state the two aspects of the project they found most useful. Of the respondents to the questionnaire 68 answered this question (although some responses only gave one aspect and one response gave three aspects). Table 2 summarises student responses to this question. It is clear that students appreciated the opportunity to meet new people on the course and to work with them in a team (For example, one student commented that the activity was a “*Good Icebreaker*”). Fifteen students agreed that development of time management and planning skills that would be used in later C/PBL activities was a useful aspect of this problem. The activity was used to introduce students to the problem solving strategy (Williams, Woodward et al. 2010) that they would be expected to use in all future C/PBL problems.

Some comments reflected the fact that some students appreciated that this problem used a very different mode of delivery to other year one teaching activities (“The problem is very different to typical university activity”) and the student-centred nature of the problem (“This allowed us to solve a problem that relates directly to us”).

Students were also asked to state the two least useful aspects of the project. Of the questionnaire respondents 51 answered this question (although the majority only stated one aspect). Table 3 summarises student responses to this question. The main issues that students had with the problem was the fact that it was based on existing scientific knowledge (so didn’t allow them to learn any new science) and issues related to time management - students had to do most of the work outside of the timetabled sessions (“Planning times that everyone is free to get together to do work was difficult”). There were very few negative comments associated with the social aspects of the problem or the development of transferable skills.

Aspect of problem	Number of responses
Developing teamwork skills	32
Developing time management & planning skills	15
Making new friends	12
Reinforcing existing knowledge	11
Developing communication skills	7
Learning new material	5
Developing IT skills	3
Developing problem solving skills	1

Table 2 2016-17 student responses to a free text questions asking them to list the two most useful aspects of the problem (N=86). ***Note:*** not all students gave two responses. 14 students did not respond to this question.

https://doi.org/10.29311/ndtps.v0i13.2680

Aspect of problem	Number of responses
The problem didn't allow for development of new scientific knowledge	18
Difficulties with time management	18
The nature of problem (too open ended, too restrictive, too easy, boring, etc.)	9
Difficulties with technology	3
Difficulties associated with report writing	3
Not enough scientific understanding to complete the problem	2

Table 3 Student responses to a free text questions asking them to list the two least useful aspects of the problem (N=86). ***Note:*** not all students gave two responses. 35 students did not respond to this question.

Conclusions

An ice breaker activity was developed to introduce year one chemistry students to their C/PBL team mates and to help familiarise them with the types of open-ended projects and problems they will be expected to work on in a chemistry degree. The activity resulted in the production of a range of student-generated learning resources ranging from printed materials to apps. At the end of the activity the majority of questionnaire respondents (N=168) agreed that their ability to work in a team had been developed by the activity. The majority of respondents also agreed that the activity helped them make friends with other people on their course, discuss science with their peers and learn how to develop a project plan. Only a minority of respondents agreed that some skills had been developed (e.g. time management and self-reflection) which suggests that students focus on getting to know their teammates and discovering how best to work together in this induction period. The data suggests that this type of activity may be an effective way of developing learning communities in chemistry degree programmes. It was also noted that it would be worthwhile investigating the influence of student expectations of university study on their perceptions of the C/PBL process at this early stage of their education.

Acknowledgements

The author would like to thank Antonio Guerreiro, Vicki Emms and Raissa Patia for helping with the delivery of this activity and the collection of data.

References

Barber, W., King, S. & Buchanan, S. (2015) *Problem Based Learning and Authentic Assessment in Digital Pedagogy: Embracing the Role of Collaborative Communities*. The Electronic Journal of e-Learning 13(2): 59-67.

Belt, S., Overton, T. & Summerfield, S. (2003). *Problem solving case studies in analytical and applied chemistry.* New Directions in the Teaching of Physical Sciences (1): 4. DOI: 10.29311/ndtps.v0i1.384

Belt, S.T. (2009). *Impacts of assignment in problem-based learning: A case study from chemistry*. New Directions in the Teaching of Physical Sciences (5): 6. DOI: 10.29311/ndtps.v0i5.454

De Jesus, K. (1995). *A Problem-Based Approach to Organic Chemistry*. Journal of Chemical Education 72(3): 224. DOI: 10.1021/ed072p224

Gutwill-Wise, J.P. (2001). *The Impact of Active and Context-Based Learning in Introductory Chemistry Courses: An Early Evaluation of the Modular Approach*. Journal of Chemical Education 78(5): 684. DOI: 10.1021/ed078p684

Hsieh, C. & L. Knight (2008). *Problem-Based Learning for Engineering Students: An Evidence-Based Comparative Study.* The Journal of Academic Librarianship 34(1): 25-30. DOI: 10.1016/j.acalib.2007.11.007

Neufeld, V.R., Woodward, C.A. & MacLeod, S.M. (1989). *The McMaster M.D. program: a case study of renewal in medical education.* Academic Medicine 64(8): 423-432. DOI: 10.1097/00001888-198908000-00001

Overton, T. (2007). *Context and problem-based learning*. New Directions in the Teaching of Physical Sciences (3): 6. DOI: 10.29311/ndtps.v0i3.409

Perrenet, J. C., Bouhuijis, P.A.J. & Smits, J.G.M.M. (2000). *The Suitability of Problem-based Learning for Engineering Education: Theory and practice.* Teaching in Higher Education 5(3): 345-358. DOI: 10.1080/713699144

Ram, P. (1999). *Problem-Based Learning in Undergraduate Instruction. A Sophomore Chemistry Laboratory.* Journal of Chemical Education 76(8): 1122. DOI: 10.1021/ed076p1122

Reynolds, F. (1997). *Studying psychology at degree level: Would problem-based learning enhance students' experiences?* Studies in Higher Education 22(3): 263-275. DOI: 10.1080/03075079712331380886

Savin-Baden, M. & K. Wilkie (2006). Problem-based learning online. Maidenhead, Open University Press.

Summerfield, S., Overton, T. & Belt, S. (2003). *Peer Reviewed: Problem-Solving Case Studies*. Analytical Chemistry 75(7): 181 A-182 A. DOI: 10.1021/ac031272y

Williams, D.P., Woodward, J.R., Symons, S.L. & Davies, D.L. (2010). *A Tiny Adventure: the introduction of problem based learning in an undergraduate chemistry course*. Chemistry Education Research and Practice 11(1): 33-42. DOI: 10.1039/C001045F

Williams, D.P. (2017). *Learn on the Move: A Problem-Based Learning Induction Activity for New University Chemistry Students*. J. Chem. Educ. *94* (12), 1925–1928. DOI: 10.1021/acs.jchemed.7b00399

Wood, D.F. (2003). *Problem based learning*. BMJ 326(7384): 328-330. PMCID: PMC1125189