THE RELEVANCE OF CHEMISTRY PRACTICALS - FIRST YEAR STUDENTS' PERSPECTIVE AT A REGIONAL UNIVERSITY IN VICTORIA, AUSTRALIA

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ABSTRACT

The use of laboratory practical sessions in chemistry to enhance student learning is common practice but, student perspectives of the relevance of this experience to their learning is difficult to find. A unique situation arose with a cohort of first-year undergraduate students where they completed one introductory chemistry course with minimal laboratory component, followed by a second introductory chemistry course with a laboratory component included. Upon completion of both chemistry courses the students were surveyed to gauge their perceptions, attitudes and experiences relating to chemistry laboratory sessions and whether they aided their understanding of chemical concepts covered in lectures and tutorials. Students (88%) considered the laboratory work to be essential and/or important in aiding their learning of chemistry, highlighting that their learning was enhanced due to the cross-over between theory and practice, while also gaining a variety of laboratory skills. A more diverse range of laboratory activities was suggested, but some students noted that they appreciated some skills repetition. Incorporating a combination of introductory and inquiry based sessions could meet the needs of both of these groups of students, while enhancing skills in other areas.

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INTRODUCTION

The role of chemistry practicals in laboratories is well established at all levels of chemical education (Adane & Adams, 2011; Reid & Shah, 2007; Tsaparlis, 2009). They have served as an essential component in this regard since the origin of the use of laboratory methods in science teaching (Garnett, Garnett, and Hackling, 1995; Hofstein & Lunetta, 2004; Hofstein & Mamlok-Naaman, 2007). At an undergraduate level in higher education, students' practical laboratory experience relates to material taught in lectures and tutorials. However, of greater importance is the need to see the "hands-on" laboratory time as part of a wider process of learning in view of enriching the whole laboratory experience, enabling such experiences to contribute more effectively to the overall learning of students in chemistry (Achor, Kurumeh, & Orokpo, 2012; Reid & Shah, 2007). During such chemistry practicals, students are provided with a work guide (manual), appropriate materials and equipment which help them to investigate scientific problems and assist with understanding theories and principles covered in lectures and tutorials (Adane & Adams, 2011). There are reports that emphasize teaching a science course with the help of laboratory experiments are more enjoyable and stimulating to students than teaching the same subject matter only through lectures (Hofstein, 2004).

Chemistry practical classes offer several opportunities to students such as: handling chemicals safely with confidence; gaining hands-on experience in using instruments and apparatus; developing scientific thinking and enthusiasm for chemistry; developing basic manipulative and problem solving skills; providing opportunities for students to be investigators of the experimental work, to identifying chemical hazards and learning to assess and control risks associated with chemicals (Achor et al., 2012; Adane & Adams, 2011; Lagowski, 2002). All of these develop highly regarded qualities in a potential graduate further highlighting the importance of exposing students to chemistry practicals in the laboratory.

Regionally located in Western Victoria, at the University of Ballarat (UB) chemistry is delivered at first year level as the SCCHE1011 and SCCHE1012 courses in the first and second semesters respectively, with SCCHE1011 being a prerequisite for SCCHE1012. At first year level both these courses are a key component (core course) of certain programs (such as Biomedical and Food and Nutritional and Sciences), whilst only SCCHE1011 is required for other programs such as Metallurgy, Geology and Education with the option of doing SCCHE1012 as an elective. As such in a typical year about 130-140 students are enrolled in SCCHE1011 decreasing to about 70-80 for SCCHE1012 in the second semester.

Over the period from 2010-2012, as the overall enrolment numbers and demand for the SCCHE1011 course expanded, the practical component was removed from the course content with the view of sustaining the increasing demand on resources and space to conduct the chemistry practical's at UB. As a result students in programs that are required to complete both chemistry courses only had the opportunity to undertake chemistry practicals in SCCHE1012 in the second semester and minimal in SCCHE1011 during the first semester. This resulted in a unique cohort of first year undergraduate students which provided an ideal group to further gauge their perceptions, attitudes and experiences relating to chemistry practical's as a medium of ascertaining greater than before appreciation of the chemical concepts being covered in lectures and tutorials.

Furthermore, a prior knowledge of chemistry is not a prerequisite for prospective students to enrol in any of the undergraduate programs at the University of Ballarat. Compounding this with the fact that the university enrols relatively large numbers of mature age students, it was even more prudent to establish the relevance of chemistry practical activities in laboratory classes from this unique cohort of first year undergraduate students perspective at the University of Ballarat. In this paper we seek to analyse and rationalise the thoughts, experiences and perceptions of this unique cohort of students about chemistry practical's as a medium of teaching and learning in view of understanding the respective theoretical concepts of chemistry covered in lectures and tutorials?

METHODOLOGY

With ethics committee approval, this study was conducted as a descriptive and exploratory investigation based on a formative evaluation (Ross, 2005; pp.4-5) by using a questionnaire based survey that had a set of 10 questions presented as a mixture that required qualitative and quantitative responses as follows:

- Do you consider practical work essential and/or important towards your learning for the chemistry course you have undertaken?
- What do you believe are possible reasons why it is important to include chemistry practical work as part of your learning for the chemistry course you have undertaken?
- The things I particularly 'liked' about the chemistry practical component of the course were.
- The things I particularly 'disliked' about the chemistry practical component of the course were.
- The chemistry practical assessment task has a weighting of 32 % of the overall assessment in SCCHE1012 course. How do you feel about this weighting?
- Do you believe that the chemistry practical assessment has assisted you in understanding what helps you to learn best compared to when you are not required to undertake practical work?
- How did you rate the following process of undertaking chemistry practical's that were provided in this course?
- Were there any barriers you encountered whilst being exposed to chemistry practicals?
- Please indicate the degree of importance you attribute to the implementation of chemistry practical's as part of your overall learning experience compared to other assessable components, namely tutorials and Online Web Learning (OWL) assignments.
- Are there any other areas of improvement that the lecturer could implement that could help students participate and engage in chemistry practical's more effectively as part of an assessment task for the chemistry course you have undertaken.

The questionnaire was given to the unique cohort of first year undergraduate students undertaking the SCCHE1012 course who were recruited to complete the survey during the last week (week 12) of their second semester of study in 2012. Participants were recruited through an advertisement that was posted on the Moodle course page for SCCHE1012, as well as being conveyed verbally in lectures/tutorials/practicals by the researchers involved in this project. Furthermore, participants were required to complete the survey questionnaires either through survey Monkey or hard-copy, whichever was more convenient for them. The findings associated with the surveys involved the formulation of descriptive statistics and the grouping of the qualitative responses by theme, with the quantitative data being analysed using a Likert scale (1 – 5, with 5 being the highest value and a score of 1 being the least).

RESULTS AND DISCUSSION

Data was obtained from 34 students which represented about 46 % of the total enrolment numbers for the introductory SCCHE1102 chemistry course in semester 2 of 2012. This unique cohort of students included many mature age students (20 %), who may or may not have had any prior knowledge/learning of chemistry before commencing their undergraduate programs. In addition all of these students lacked any exposure to chemistry practicals in the initial introductory chemistry course SCHCHE1011. This cohort of students consisted mostly of those undertaking a health science major in either Biomedical or Food and Nutritional Science. Furthermore, the majority of this cohort of students was domestic Australian students (95 %) predominantly from a regional and/or rural background.

The students overwhelmingly agreed (88 %) with the statement that they consider laboratory work to be essential and/or important to their 'learning' of chemistry. The main reasons highlighted for why the students felt laboratory work is important were the cross-over between theory and practice to enhance learning (80 %) and the additional skills gained (90 %). The skills specifically mentioned related to observation (67 %), deduction and interpretation of results (60 %), having the chance to use new equipment (63 %) and key writing skills (67%). Similar results were found by Adane and Admas (2011) who surveyed chemistry students from Ethiopia. These key ideas fit with the laboratory work objectives as described by Garnett et al., (1995) of laboratory work being used to develop conceptual learning, enhance techniques and manipulative skills, investigation skills and affective objectives. They also match with those described by Reid and Shah (2007) who noted that laboratory work should aim to provide skills relating to learning chemistry, practical skills, scientific skills and general skills which included skills such as reporting, presenting and discussing.

This was the first experience of a University chemistry laboratory for these students, with many of them also having no experience of chemistry at the senior secondary level. The consequence of this was that many of them specifically highlighted the use of new equipment as being important to them in their laboratory experience. Many students showed initial signs of apprehension about entering the chemistry laboratory and often doubted their ability to successfully undertake practical activities. Yet, on reflection at the end of the semester, when this survey was completed, only 4 % of students said they found the practicals to be hard.

The key aspects the students liked about the laboratory experience were the overlap between the lecture topics and the practical component (67%), as well as encountering new knowledge of chemical science (48%). They also highlighted that their increased understanding of what a chemical practical activity involves (63%) was another aspect they liked. Only 19 % of students noted that they liked to write and submit each practical report.

While the importance of laboratory work was acknowledged, many students highlighted that they would prefer a more diverse range of activities to enhance both their understanding of theoretical aspects and their laboratory skills. This may have impacted on the small percentage of students (15%) who said they lacked motivation for practicals. The laboratory activities undertaken by this cohort of students primarily fell into the areas of experiences and exercises (Garnett et al., 1995; Woolnough & Allsop, 1985), with most being 'recipe style' sessions. This particular cohort undertook a number of practical activities including Molar Volume of a Gas, Acid Base Titration, Determining a Solubility Product and Vitamin C Content of Fruit Juice. This means that the students did not have the opportunity to identify problems or formulate hypotheses and then develop their own experiments, as occurs with Inquiry and problem-based laboratory work (Domin, 1999; Hofstein & Lunetta, 2003; Johnstone & Al-Shuaili, 2001; McGarvey, 2004; Tsaparlis, 2009). Ideally laboratory work should be a combination of introducing the necessary prior knowledge, as well as providing students with an opportunity to undertake open-ended investigations, with an inquiry framework being an effective way to achieve this (Reid & Shah, 2007).

Interestingly, when it came to barriers, 60 % of the students commented that were no barriers encountered relating to the laboratory sessions. While trained scientists understand the importance of writing skills, as has been highlighted in the Science Threshold Learning Outcomes (TLOs) (Jones & Yates, 2011), over 40 % of students stated they disliked having to write and submit laboratory reports. Of the barriers highlighted, 20 % of students indicated that finding time to write reports was an issue for them, with 15 % saying they were unmotivated when it came to practical activities. While these percentages are small they fit with the need to highlight the relevance of written communication skills to scientists (Reid & Shah, 2007). This suggests that a greater emphasis needs to be placed on highlighting and explaining to students the importance of communication skills to scientists. It may also help to provide clear information about this aspect into the future.

The need for greater input into introductory sessions and information about the procedure was also suggested by the students. This fits with the literature (Johnstone & Al-Shuaili, 2001; Reid & Shah, 2007; Tsaparlis, 2009) which highlights the need to have valuable pre-laboratory experiences in order to gain the most from a laboratory session and to alleviate the issues associated with information overload on students. While traditionally pre-laboratory experiences involved pre-lab quizzes or talks, they now tend to focus on using information and communications technology (ICT) to provide a more comprehensive system to enhance the learning of students, by incorporating videos, animations, simulations and quizzes (McKelvy, 2000; Schmid & Yeung, 2005). The use of this technology for pre-laboratory work in the chemistry courses at UB needs to be investigated, as it is likely to enhance the overall experience of the students. A contradictory aspect noted was that some students commented that the lack of variation (e.g. a number of titrations) within the laboratory exercises was a barrier, while other students highlighted that as their previous laboratory experience was minimal to non-existent they appreciated some repetition. This challenge of meeting the needs of a disparate group of students can be addressed by providing greater opportunity for laboratory experiences.

The practical aspect of the course has a weighting of 32 %, which was considered to be ‘about right’ by 61% of the respondents. Comments about this included that as practical skills are important they should be weighted accordingly. When specifically asked about the level of importance students placed on the laboratory work compared to tutorials and Online Web Learning (OWL) assignments, 89% indicated they were (very) important.

It is well understood that people learn in different ways (Hofstein & Lunetta, 2003), however students may not take the time to evaluate this from a personal perspective. When asked whether the practical component assisted with their learning, 64% of respondents said ‘yes’. This was a unique cohort of students who had completed one course of chemistry at undergraduate tertiary level with minimal practical component included and another with a practical component. When asked to elaborate on this answer, most noted that they found doing practical work helped them with their understanding, as it illustrated the theory, meaning their understanding increased. While a number of students commented that they like ‘hands-on’ work and ‘learn by doing’ only one student used the terminology of being a kinaesthetic and visual learner. This suggests that more needs to be done in helping students understand the way they learn best and most effectively.

CONCLUSIONS

Laboratory work is considered by students to be a very important part of their ‘learning’ of chemistry as many important skills are gained and their understanding of theoretical concepts is enhanced. The key skills identified by the students included refining their observation and deduction skills, having the opportunity to use new equipment and learning to interpret results. While some students highlighted that they liked writing reports based on their laboratory work as it enhanced their writing skills, a greater number disliked this aspect and did not identify the skills learnt with this task as being important. A weighting of 32% for the laboratory component of the course was seen by the students as being appropriate as it emphasised the importance of this aspect of the course.

The range of laboratory activities undertaken by the students is also seen as being important, with a wider range providing greater opportunities to aid their understanding of a broader range of theory. However, when the previous chemical experience of the cohort of students is broad (non-existent through to completing senior secondary chemistry), some repetition of skills is key to helping less experienced students feel comfortable in the laboratory setting. Adding some inquiry based sessions to the laboratory program could help overcome some of these issues while also allowing students to improve problem solving skills, participate in group work and enhance their oral communication skills. Furthermore, in view of extrapolating the findings from this current study, it would be viable to consider a larger population survey in any research conducted as a follow up.

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