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RESEARCH ARTICLE

Development of a pharmacy undergraduate laboratory class which combines compounding, natural products, and analytical chemistry

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Abstract

A new three-hour laboratory class was developed integrating concepts of compounding, natural products and analytical chemistry. Students performed thin layer chromatography to detect the active constituent of tea tree oil (1,8-cineole; eucalyptol), and then compounded zinc paste, incorporating tea tree oil. The laboratory class was implemented into a discipline-specific unit, Physical Pharmaceutics and Formulation A, and completed by a cohort of 187 first year pharmacy students in October 2018. This new integrated model for the laboratory resulted in higher student satisfaction scores for the laboratory classes; measured on a Likert scale (from 1 to 5), with a mean score of 4.12 in 2017 which increased to 4.50 in 2018. Overall student satisfaction of the unit also increased from a mean score of 4.08 to 4.32. This laboratory class forms the first activity Sydney Pharmacy Schools suite of indigenous plant laboratory activities in the development of its complementary medicines curricula.

Keywords: *Complementary Medicines, Pharmacy, Integrated, Laboratory, Thin Layer Chromatography, Analytical Chemistry, Undergraduate*

Introduction

The integration of basic sciences with clinical therapeutics is an important strategy in healthcare education. The 2016 United States Accreditation Council for Pharmacy Education standards state that the learner should be able to "apply the foundational sciences to the provision of patient-centred care" (Accreditation Council for Pharmacy Education, 2015). Similarly, the 2012 Australian and New Zealand Accreditation Standards for Pharmacy Programmes state the need for "congruency with contemporary pharmaceutical sciences, pharmacotherapeutics and pharmacy practice and the pharmacy learning domains" (Australian Pharmacy Council, 2012). The literature describes a wide variation in the types of integration in pharmacy education (Pearson & Hubball, 2012), from standalone courses with integrated laboratory sessions to fully integrated programmes (Islam *et al*., 2016). Educators have implemented innovative approaches to improve the relationship of pharmaceutical sciences to pharmacy practice, for example the Patient Care Project (Brown *et al*., 2009). Importantly, integration of pharmaceutical science and pharmacy practice has been shown to enhance students' acquisition of knowledge, and abilities to apply content and concepts (Poirier *et al*., 2016).

In Australia, products made from indigenous plant-based medicines are categorised as complementary medicines (Therapeutic Goods Administration, 2018). An estimated 50% of Australians used some form of complementary medicine (medicinal) product during 2017 (Harnett *et al*, 2019). Of these, 11% used plant based essential oils and 9.5% herbal medicines (Steel *et al*., 2018). The majority of these products are purchased in pharmacy outlets (Waddington *et al*., 2015). Given the prevalent use and ease of access of complementary medicines in community pharmacy, key stakeholders continue to recommend that education in complementary medicines for pharmacy students is essential (Ung *et al*., 2016; 2017). Despite this, training and education in pharmacy schools remains limited, thus providing an opportunity to develop new methods of integrating complementary medicines into curricula.

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In the Bachelor of Pharmacy programme at The University of Sydney's School of Pharmacy, first year pharmacy students undertake discipline specific courses including human biology and chemistry and are introduced to pharmacy practice through foundation and primary care courses. In one of their core first year units, Physical Pharmaceutics and Formulation A, the authors developed and implemented a laboratory class integrating pharmaceutical science concepts to pharmacy practice. It was designed with the theme of complementary medicines with a goal of creating a suite of indigenous plant laboratories that contribute to the ongoing development of the complementary medicines curricula.

This laboratory activity addressed the following objectives:

a. Align with The University of Sydney's (the University's) 2016 strategic plan of embedding cultural competence in the curriculum, including Aboriginal and Torres Strait Islander cultures.

b. Contribute to the programme's curricula outcomes in line with the pharmacy learning domains as outlined by the Australian Pharmacy Council's Accreditation Standards (2012), especially learning domains 1 (complementary therapies); 3 (understand the sources and properties of drugs, including those of plant origin; and perform analytical methods); and 4 (formulate and compound medicines to appropriate standards for safety and quality).

This article provides a description of the development and implementation of an undergraduate laboratory class integrating pharmaceutical science concepts with pharmacy practice, using essential oil extracted from an indigenous plant.

Description

The tea tree paste laboratory class was developed by three school members, with individual expertise in pharmaceutical chemistry, complementary medicines, and extemporaneous dispensing. The aim of the laboratory class was for students to complete an analysis of tea tree oil samples using thin layer chromatography (TLC), and then practice simple compounding by preparing a zinc paste and adding tea tree oil as a medicament. A written manual containing background information relating to natural products, TLC and semisolids, and a description of experimental steps was prepared and included into the students' laboratory manual. The laboratory class was facilitated by one faculty member, a casual demonstrator, and a laboratory technician. The outline of the laboratory class was:

1. Students to complete the TLC experiment in pairs, and then analyse their results;
2. Students to individually compound zinc paste and incorporate tea tree oil;
3. Students to individually complete a two-page laboratory questionnaire and submit for assessment.

Materials

The silica TLC plates and 1,8-cineole were purchased from Sigma Aldrich (Sydney, Australia). The tea tree oil brands used were Green Action (Aldi Pty Ltd., Sydney, Australia) and Thursday Plantation (Integria Healthcare Australia Pty Ltd., Sydney, Australia). The solvents, heptane and ethyl acetate were purchased from Supelco (Sydney, Australia). White soft paraffin, zinc oxide, and starch were purchased from New Directions Australia (Sydney, Australia).

Thin layer chromatography (TLC)

In pairs, the students used TLC to determine if the chemical 1,8-cinoele (eucalyptol) was present in two tea tree oil samples. The TLC experiment was based on the British Pharmacopeia's tea tree oil monograph (British Pharmacopeia, 2019). Students were provided a pre-cut 5 × 10 cm silica TLC plate, on which they drew a perpendicular line one centimetre from the bottom of the plate and marked three crosses equidistant on the line. They then prepared three beakers, two containing 100 μL of different tea tree oil products and one containing 100 μL of the 1,8-cineole standard, to which they added 5 mL of heptane to each beaker. Each solution was spotted individually onto the TLC plate, before it was air dried, and then placed in a TLC tank containing 1 mL of ethyl acetate and 4 mL of heptane as the mobile phase. Once the mobile phase had significantly slowed (1-2 cm from the top of the plate), the students were directed to remove it from the tank, use a pencil to mark the solvent front, and air dried before the plates were sprayed with an anisaldehyde solution (0.5 mL of anisaldehyde; 10 mL of glacial acetic acid; 85 mL of methanol; and 5 mL of sulfuric acid). Drying the TLC plates with a hair dryer produces violet-brown coloured spots which mark the locations of 1,8-cineole.

Compounding

Individually, students compounded zinc paste based on the formulation described in the Australian Pharmaceutical Formulary 24 (Pharmaceutical Society of Australia, 2018). Each student separately weighed white soft paraffin (10 g), zinc oxide (5 g), and starch (5 g) using an electronic balance and placed each on separate corners of a glass slab. Around half of the white soft paraffin (not melted) was then incorporated into each of the two powders using a spatula before the two resulting semi-solid mixtures were combined. The remainder of the white soft paraffin was combined into the mixture resulting in a smooth, white paste. A well shape was then made in the mixture into which tea tree oil (1 mL) was added. The mixture was then triturated before the final product was transferred into an empty glass jar (30 g).

Completion of laboratory questionnaire

At the completion of the experimental work the students were required to complete a two-page questionnaire, answering questions based on the content of the class and their results. In the questionnaire students were required to draw the chemical structure of 1,8-cineole and a reproduction of their TLC plate including the solvent front and the observed 1,8-cineole spots. Next, they needed to calculate the retention factors for each spot and conclude whether each oil samples contained 1,8-cineole. Students also discussed whether their TLC experiment could be used to determine the concentration of the active ingredient in the oils and provide a rationale for their answer. Finally, to practice appropriate documentation of compounded products, students recorded the name of the manufacturer, batch number, and expiry date of each of the ingredients used in the preparation of the zinc paste with tea tree oil.

Evaluation

Prior to implementation into the undergraduate curriculum, the laboratory class was pilot tested among a group of 25 Aboriginal and Torres Strait Islander high school students who were participating in a summer camp on the University's campus in January 2018. Afterwards, the tea tree paste laboratory class was incorporated into one of the core courses of the Bachelor of Pharmacy programme for first year students, Physical Pharmaceutics and Formulation A. There were 187 students (67% female and 33% male) enrolled in the unit who were concurrently studying other courses including Chemistry A, Pharmacy Practice 1, and Biology (From Molecules to Ecosystems). The new laboratory class was run over two weeks in October 2018, with each class consisting of 20 to 30 students. The time allocated for the laboratory class was a maximum of 3 hours, although most students completed the activities in 2-2.5 hours.

As part of the unit, students completed five laboratory classes and each class was worth three marks, for a potential total of 15 marks towards students' final grade. These marks were awarded by the laboratory demonstrator based on satisfactory performance of the class, that is, punctual attendance; correctly completing the laboratory questionnaire; and good conduct and participation. All students who attended the tea tree paste laboratory class were awarded 3 out of 3 marks. Comparing students' performance in the final written exam for this unit, the mean mark in 2017 was 73%, which increased to 75% in 2018 (p=0.03). However, for specific multiple-choice questions relating to complementary medicines, students performed slightly more poorly, with the correctness decreasing from 93% in 2017 to 90% in 2018.

Between 2017 and 2018, the only change to the unit Physical Pharmaceutics and Formulation A unit was the incorporation of this new laboratory class. All other lectures, lecture topics, laboratory classes and teaching staff remained the same. As part of the University's standard operations, at the conclusion of every unit, students are invited to complete an anonymous unit of study survey for continuous quality improvement. In this, students are asked to provide a rating on different aspects of the unit using a Likert scale (1 = strongly disagree to 5 = strongly agree). For the statement 'Small group teaching in labs helped me to learn', the mean score increased from 4.12 in 2017 to 4.50 in 2018 (9.2% increase, p=0.003). Similarly, the mean score for student satisfaction for the entire unit also increased significantly from 4.08 in 2017 to 4.32 in 2018 (5.9% increase, p=0.015). As the only change to this unit was the addition of this new laboratory, these increases may be attributed to this new integrated class.

Students also provided written feedback in response to the question: 'What have been the best aspects of this unit of study?'. Of the 33 written responses, 19 mentioned the laboratories in some positive form. Examples of student responses included:

> *"All the labs were enjoyable - my favourite was the last lab (tea tree paste)";*
>
> *"...the laboratories were a great practical outworking of the topics learnt in lectures";*
>
> *"the pharmacy labs were excellent as they combined what we were learning about in the lectures with practical experiments that enriched our learning".*

Given that in the current structure of the curriculum pharmacy students learn compounding and dispensing skills in the third year of the programme, this integrated laboratory class was an innovative way to introduce pharmacy practice concepts during the first year which is made up of mostly foundational science units. This new laboratory class was a successful intervention to foster students' understanding of the relationship of pharmaceutical sciences to pharmacy practice.

Future plans

The tea tree paste laboratory was a novel way of integrating compounding, natural products, and analytical chemistry into a discipline specific course in the undergraduate pharmacy curriculum. When designing curricula, the authors recommend educators consider implementing similar laboratory classes for undergraduate pharmacy or chemistry students to help improve the relationship of pharmaceutical sciences to real practice. Following on from the tea tree oil example used here, in December 2018 a new laboratory activity was developed using lemon myrtle as the natural product. The TLC experiment was based on the British Pharmacopeia's citral monograph (British Pharmacopeia, 2019), and spots were analysed under an ultra-violet lamp. Further, lemon myrtle oil was added to compounded cetomacrogol cream. With the successful development of two laboratory activities, the authors are trialling different plants to build a suite of indigenous plant laboratories to contribute to the development of the complementary medicines curricula. Similar integrated laboratory classes could be adopted in other institutions based on different natural products relevant to their culture and lands.

Conclusion

A laboratory class integrating complementary medicines, analytical chemistry, and pharmacy practice (compounding) was developed and implemented in an undergraduate pharmacy programme. Given that in the current curriculum, students learn dispensing and compounding skills in their third year, this was an innovative way to introduce pharmacy practice concepts during the first year, which is made up of mostly foundational science units. Further, this class was a novel way to embed cultural competence in the pharmacy curricula, through the use of indigenous plants.

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Conflict of interest statement

The authors declare no conflicts-of-interest.

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