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RESEARCH ARTICLE

Implementing a longitudinal poster project to engage pharmacy students beyond the classroom in a foundational sciences course

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Abstract

Introduction: Poster projects and presentations can provide engagement and skill-building opportunities for students. A group poster project was incorporated into a first-year required genetics and pharmacogenomics course. Rough drafts were due for the project throughout the term, which coincided with course topics. The objective of this study was to determine the impact of a longitudinal poster project on pharmacy students' perceptions of learning, presentation skills, and success in future presentations. **Methods:** Students in a Doctor of Pharmacy programme were surveyed via Google Forms in 2018 before and after completing the poster project. The original cohort of students were surveyed again in 2020. Data were analysed with Graphpad Prism software. **Results**: Students responded positively to survey questions gauging their perception of the project's value as a learning tool, especially for reinforcing and applying course concepts. Overall, students saw the benefit of completing poster rough drafts and believed the poster was helpful in preparing and/or presenting future posters. **Conclusions**: A similar project could be built into any foundational course in a Doctor of Pharmacy programme. However, care should be taken to provide appropriate feedback and mentorship to students to optimise the benefits of learning and development of poster presentation skills.

Introduction

In recent years, numerous studies have reported the benefits of active learning and engagement activities for students, including in pharmacy degree programmes (Stewart *et al*., 2011). However, others have outlined the barriers to incorporating active learning into foundational pharmaceutical sciences courses in pharmacy degree programmes, including the concern that all required course content will not be covered if class time is allotted to active learning activities (Brazeau, 2004; Kennedy, 2019). In addition, there is a very limited amount of literature describing unique out-of-class approaches to support learning in these types of courses. Group projects, or formal cooperative learning, are examples of assignments where groups of students are expected to complete a task together over a given timeframe (Davidson & Katopodis, 2022). Group projects are a type of engagement activity that can be designed to use little to no class time while maintaining the benefits of active learning (Love *et al*., 2014). An added advantage of group projects is peer-to-peer instruction (Versteeg *et al*., 2019), which in the project described herein occurs during the preparation phase, as group members work together to identify and include appropriate information in an optimal format.

Posters are a widely accepted format for scientists and researchers to share their current research with a large audience in a formal setting (Sousa & Clark, 2019). While many types of projects could be used for

cooperative learning, poster projects, in particular, require students to retain and apply course content, as well as practice their oral communication skills in a format that they may use again in their career if they choose to conduct and share research as a clinical pharmacist (Grey *et al*., 2022). Professors from various institutions across the world have implemented poster projects into their courses over the past few decades, adapting poster projects and presentations for a wide array of disciplines, levels of education, and learning objectives (Hess & Brooks, 1998; Wheland *et al*., 2009; Rauschenbach *et al*., 2018). Within pharmacy degree programmes specifically, poster presentations have been incorporated into the didactic and experiential curricula in a variety of ways. Usually, poster presentations are used to summarise data derived from capstone projects, Advanced Pharmacy Practice Experiences (APPE), and research electives (Wuller, 2010; Ramsauer, 2011; Harirforoosh & Stewart, 2016; Henchey *et al*., 2020). However, they can also be utilised as projects within required didactic courses (Nowak, 1998). Most reported opportunities in pharmacy programmes that resulted in a poster presentation have been geared toward students in the later part of their professional education. This brings into question the impact that a poster presentation might have on pharmacy students if incorporated into a foundational pharmaceutical sciences course during their first professional year (PY1).

The majority of published studies regarding poster projects within pharmacy education have focused on involving pharmacy students in original research, requiring them to play a part in all phases of the project, from the project proposal, methods, data collection, and presentation (Hess & Brooks, 1998; Wheland *et al*., 2009; Rauschenbach *et al*., 2018; Henchey *et al*., 2020). One study within a Doctor of Pharmacy programme has assessed a poster project and presentation itself as an innovative learning tool independent of an original research experience. That study, published in 1998, describes a poster presentation that was implemented within a medicinal chemistry course (Nowak, 1998). In this example, second professional-year pharmacy students, in groups of three to four, worked on a project that culminated in a poster presentation and a term paper on a novel drug or drug target (Nowak, 1998). Overall, there is limited published research on this topic, especially in regard to pharmacy education.

As the realm of higher education evolves from instructors solely lecturing at the front of the room to a student-centred active learning model, pharmacy education staff are seeking out unique approaches that use minimal valuable lecture time to teach foundational concepts and connect them with clinical application. An out-of-class poster project assignment, such as the one described here with its novel design and curricular placement, maybe a beneficial educational tool that instructors could implement to reach that goal. The objective of this study was to determine the impact of a longitudinal poster project and presentation on students' perceptions of its effects on learning, presentation skills, and anticipated or actual success in future presentations. The approach to this study assessed perceptions over several years to determine if opinions regarding the poster project changed over time and whether students had applied skills learned during the process to subsequent poster projects.

Methods

The genetics/pharmacogenomics poster project and presentation discussed in this paper were developed as part of the required PY1 Principles of Genetics and Genomics course in a College of Pharmacy and Health Sciences (COPHS) at a private university. For the project, teams of six students chose any disease state that included a genetic component at the beginning of the term, which differed from other poster presentation topics for that year. Each part of the poster project (six parts total, including one section on Pharmacoeconomics that was graded separately) was due as a rough draft that should be worked on and submitted as a team sequentially throughout the term as related content is covered in the course. This process encourages students to work on the project longitudinally and provides touchpoints for mentoring students on the accuracy/appropriateness of content, as well as formatting. At the end of the term, each team has a chance to resubmit one of their rough drafts for a better grade (Redo) before the poster is finalised, allowing them to gain additional feedback before printing the poster and completing the final presentation. The presentations occur at a mock conference with COPHS faculty, other students, residents, and administrators to emulate what students might encounter if they present a poster at an academic conference. The rough drafts account for 60%, the final presentation accounts for 35% (Appendix A), and a quiz to ensure students review all posters accounts for 5% of the total poster grade. The poster is prepared in PowerPoint, and rough drafts are submitted to dropboxes where grading/feedback is provided.

The sections of the poster encompass various aspects of a disease state, including description, risk factors, testing, a summary of treatment options, pharmacology of one treatment option, and the

pharmacogenomics and pharmacoeconomics of the chosen treatment option. Although each student in the group presents one section of the poster and receives an individual grade, the project instructions recommend that the group works as a team on all rough drafts and the final poster format, which are graded as a group. The project requires students to review foundational concepts from the course and think critically about the therapeutic use of genetics/pharmacogenomics. Thus, the project was primarily developed to enhance students' understanding, retention, and clinical application of coinciding course concepts through the process of preparing and then presenting a poster. The secondary outcome of the poster project was to expose PY1 students to this process to help them develop the skills to design a poster from start to finish and enhance their verbal communication through the presentation.

Several electronic surveys were utilised in this study to assess student perceptions regarding these aspects of the poster project. These surveys were developed based on similar published questionnaires as templates (Marcinak *et al*., 2018). Efforts were made to optimise the length (pre/post - 16/12 questions, follow-up - 18 questions) and clarity of the surveys to obtain meaningful data, as well as improve response rates. PY1 students were surveyed in the spring of 2018 at the start of the course and after they completed the poster project. Respondents were asked to choose a unique six-digit number to match their pre- and post-survey responses for optimal analysis and to maintain anonymity. To optimise response rates, for the pre/post surveys, students received a 0.5% bonus on their final grade for the course for each survey completed, for a potential total of 1%. Students who did not wish to participate were provided with a different assignment (equal in time and effort to the survey) for an equal bonus in the course. The recruitment e-mail indicated that each survey should take approximately 15 minutes to complete for a total of 30 minutes for 1% bonus. One student chose to complete the alternative assignment instead of taking either survey. For this assignment, they were asked to write a brief summary (about half a page) on the topic of the use of presentations and posters to benefit students. Students who only responded to either the pre-survey or the post-survey were excluded from the results. Students were provided information about each survey in an initial e-mail with no reminders and given one week to respond. The purpose of the pre- and post-surveys was to assess the students' perception of the benefit of the project toward their understanding, retention, and clinical application of genetics/pharmacogenomics course concepts, as well as their perception of the impact of the project on their confidence presenting future posters, and the value of having assigned drafts for the project. This was followed up in the summer of 2020 by surveying the same cohort that was enrolled in the course in 2018 to assess their perception of the project several years later. Again to optimise response rates, students who completed the follow-up survey were able to submit their names through a separate link for a chance to win a $25 gift card. Thus, responses to this survey were also anonymous. Students were provided information about the follow-up survey in an initial e-mail, sent two e-mail reminders, and given three weeks to respond. Participation was not required, so reasons for non-response were not collected for any of the surveys.

Data were collected through Google Forms and analysed through the GraphPad Prism software (Version 8). Likert scale questions were converted to numerical data (Strongly Disagree = 1, Disagree = 2, Neither Agree nor Disagree = 3, Agree = 4, and Strongly Agree = 5) for statistical analysis to compare pre and post-survey responses. The D'Agostino-Pearson normality test was used to assess the normality of each data set. Normally distributed data were compared using either unpaired *t*-tests with Welch's correct or paired t-tests. Data not normally distributed were compared using Mann-Whitney tests or Brown-Forsythe and Welch's ANOVA. Follow-up survey data were reported with descriptive statistics only. Post hoc analyses were conducted to see if future plans or previous poster experience affected any of the outcomes. This research was approved by the COPHS Institutional Review Board (COPHS-IRB# 28 and 92).

Results

There were 60 first-year pharmacy students enrolled in this course in 2018 who participated in and completed the project. Fifty-nine students completed the pre-survey, and 56 students completed the post-survey. Based on the six-digit code, 45 participant pre/post surveys were matched, resulting in a final response rate of 75% (N = 45). The response rate for the follow-up study of the original cohort as PY4 students in 2020 was 45% (N = 27). The demographics of student respondents are shown in Table I. The majority of respondents in the pre and post-surveys were female (77.8%, N = 35), which is similar to the 71.7% of females in that cohort, and had no previous degree (82.2%, N = 37). In their first year, most respondents planned to either complete a post-graduate residency or become employed at a community pharmacy upon graduation, and this remained true in their fourth year (PY4, follow-up survey), with slight changes in percentages.

Table I: Demographics of survey respondents

	PY1[a] (n = 45) Pre/Post-survey n (%)	PY4[b] (n = 27) Follow-up n (%)
Age (years)		
Under 20	20 (44.4)	
21 - 24	19 (42.2)	
25 - 30	4 (8.9)	
31 - 40	2 (4.4)	
Over 41	0 (0)	
Gender		
Male	10 (22.2)	
Female	35 (77.8)	
Previous education		
Pre-pharmacy/Prerequisites	37 (82.2)	
Bachelor's degree	7 (15.6)	
Master's degree	0 (0)	
Doctor of Philosophy degree	0 (0)	
Other	1 (2.2)	
Future plans		
Post-graduate residency	14 (31.1)	12 (44.4)
Post-graduate fellowship	2-3 (4.4 - 6.7)	1 (3.7)
Employment in community	13-16 (28.9 - 35.6)	12 (44.4)
Employment in a hospital	7-9 (15.6 - 20.0)	1 (3.7)
Other	5-7 (11.1 - 15.6)	1 (3.7)

[a]PY1 = first professional year; [b]PY4 = fourth professional year

Overall, students responded very positively to survey questions gauging their perspective on the project's value as a learning tool, specifically in regard to reinforcing course concepts (88.9% and 88.9% agreed/strongly agreed in pre- and post-surveys, respectively) and improving their ability to apply (88.9 and 93.3% agreed/strongly agreed in pre- and post-surveys, respectively), and retain such concepts (82.2 and 82.2% agreed/strongly agreed in pre- and post-surveys, respectively), as shown in Table II. Students responded significantly more in agreement to the statement on applying course concepts in the post-survey than in the pre-survey. However, there were only slight but insignificant increases in agreement for reinforcing and retaining course concepts in the pre- and post-surveys. Although levels of agreement waivered in the follow-up (PY4) survey for these statements, a majority of respondents still agreed/strongly agreed that the project reinforced (85.2%), as well as helped them to apply (81.5%) and retain (70.4%), course concepts (Table II).

Table II: Survey respondent perspectives on usefulness of the project as a learning tool.

	PY1[a] (n = 45)		PY4[b] (n = 27)
	Pre-survey M (SD)[c, d]	Post-survey M (SD)	Follow-up M (SD)
Completing the poster project will/did help reinforce course concepts.	4.13 (0.59)	4.31 (0.73)	4.07 (0.62)
Completing the poster project will/did help me apply the course concepts.	4.18 (0.61)	4.44 (0.69)[e]	4.04 (0.76)
Completing the poster project will/did help me retain the course concepts.	4.09 (0.67)	4.18 (0.94)	3.70 (1.03)
Rough drafts of sections due over the term will be/was a useful way to complete the poster and prepare for the presentation.	4.18 (0.65)	4.76 (0.48)[e]	4.52 (0.58)
Looking back on the group effort, everyone contributed to preparing the final poster.			4.00 (1.11)
Looking back, all members of the group contributed equally to all sections of the poster project.			3.63 (1.24)

[a] PY1 = first professional year; [b] PY4 = fourth professional year; [c] Likert scale key: 5 = strongly agree; 4 = agree; 3 = neutral; 2 = disagree; 1 = strongly disagree; [d] Mean (Standard deviation; [e] $p < 0.05$ Comparison of post-survey results with pre-survey results

Delving into the project layout, students saw rough drafts being due throughout the term as useful (86.7% and 97.8% agreed/strongly agreed in pre- and post-surveys, respectively) (Table II). As anticipated, PY1 students responded significantly more in favour of rough drafts in the post-survey. The respondents in the follow-up (PY4) survey also overwhelmingly responded in favour of rough drafts as a useful way to complete the project, with 96.3% of students choosing to agree/strongly agree. Students were generally successful in scoring rough draft sections, and this improved further after the allowed one rough draft section redo (seven out of ten teams chose to redo a section of their posters, none for section one, two for sections two to four, and one for section five), suggesting that they had learned from the process and were able to make corrections, both in content and formatting (Table III). Students also excelled at their poster presentations, which were evaluated based on printed and orally presented information, poster formatting, and presentation skills (Table III). Finally, although a direct correlation of final grades to the poster project cannot be completed due to confounding variables, students did well in the course, with a class average of 81.8, and only one-course failure after normalising for the bonus points received for completing the surveys (Table III).

Table III: Student performance for the poster project and in the course

	Before redo	After redo	*p*-value[b]
	M (SD) or N		
Rough drafts			
Section 1	90.0 (5.5)	NA	
Section 2	86.7 (8.0)	91.5 (5.1)	0.0005
Section 3	84.0 (14.4)	91.0 (9.5)	0.0005
Section 4	87.5 (6.5)	91.5 (6.8)	0.0005
Section 5	84.0 (6.3)	85.5 (6.9)	0.03
Poster presentation		91.4 (1.2)	
Final poster grade		90.9 (1.3)	
Final course grade[a]		81.8 (6.2)	
Final course letter grade (As, Bs, Cs, Fs)[a]		10, 25, 24, 1	

[a] Normalised for bonus given for completing survey; [b] Before versus after redo

Digging deeper into how the teams approached the project, students in the follow-up (PY4) survey were also asked to reflect on team members' contributions to the project (Table II). These questions ('*Looking back on the group effort, everyone contributed to preparing the final poster*'; '*Looking back, all members of the group contributed equally to all sections of the poster project*') sought to deduce whether students split the project up by rough draft sections or if there was collaboration among the team members on each of the required drafts and hence learning about all topics by all students. Overall, the majority of students in the follow-up (PY4) survey agreed/strongly agreed with both statements, although fewer students agreed to the second statement compared to the first (81% and 63% agreed/strongly agreed, respectively) (Table II). Open response feedback was also solicited from the follow-up (PY4) survey respondents in regard to why students did or did not contribute equally to all sections of the project. The student comments focused on two main themes: (1) Mastery of course concepts (or lack thereof) impacted the ability to contribute to the project, and (2) Rough draft sections were not equally difficult, leading to unequal contribution.

Aside from gauging the perceived usefulness of the project as a learning tool, the perceived value of the project as a stepping-stone for future poster presentations was also assessed. Two-thirds of PY1 students who responded to the survey had no experience with a previous poster presentation (Table IV). Given this limited amount of previous experience, almost all PY1 students agreed in both the pre- and post-surveys that preparing and presenting the project would help them prepare and present future posters (93.3% and 100% agreed/strongly agreed for preparing; 93.3 and 95.6% agreed/strongly agreed for presenting, in pre and post-surveys, respectively) (Table V). When assessing students' perceptions of their confidence in presenting a poster, the responses were varied (Table V). Only 37.8% of PY1 respondents agreed/strongly agreed that they were confident in their poster presentation skills prior to the start of the course,

which unexpectedly increased to 62.2% in the post-survey. However, 88.9% of respondents already agreed/strongly agreed in the pre-survey that the poster project would increase their confidence level to present a poster in the future. This percentage was even higher in the post-survey, indicating that the project did increase their confidence (Table V).

Table IV: Previous and subsequent poster presentations completed by survey respondents

	PY1[a] (n = 45) Pre/Post-survey n (%)	PY4[b] (n = 27) Follow-up n (%)
Presentations before project		
Zero	30 (66.7)	19 (70.4)
One	5 (11.1)	2 (7.4)
Two	2 (4.4)	4 (14.8)
Three	3 (6.7)	1 (3.7)
Four or more	5 (11.1)	1 (3.7)
Presentations after project		
Zero		0 (0.0)
One		15 (55.6)
Two		3 (11.1)
Three		5 (18.5)
Four or more		4 (14.8)

[a] PY1 = first professional year; [b] PY4 = fourth professional year

Table V: Survey respondent perspectives on usefulness of the project in regard to future projects

	PY1[a] (n = 45)		PY4[b] (n = 27)
	Pre-survey M (SD)[c, d]	Post-survey M (SD)	Follow-up M (SD)
Preparing the genetics poster presentation project will/did help me prepare future posters.	4.33 (0.60)	4.53 (0.50)[e]	3.89 (0.70)
Presenting the genetics poster presentation project this term will/did help me present future posters.	4.36 (0.77)	4.60 (0.65)	4.04 (0.65)
I feel/felt confident in my poster presentation skills (before the genetics poster presentation project).	3.18 (0.91)	3.56 (0.94)[e]	3.22 (0.89)
Presenting the genetic poster project will/did increase my confidence level in presenting a poster in the future.	4.04 (0.82)	4.38 (0.72)[e]	3.85 (0.60)
I would/do include the genetics poster presentation project on my resume/CV.	3.42 (0.97)	3.71 (0.99)[e]	3.70 (1.32)

[a] PY1 = first professional year; [b] PY4 = fourth professional year; [c] Likert scale key: 5 = strongly agree; 4 = agree; 3 = neutral; 2 = disagree; 1 = strongly disagree; [d] Mean (Standard deviation); [e] $p < 0.05$ Comparison of post-survey results with pre-survey results

A majority of respondents in the follow-up (PY4) survey still indicated that they had completed no poster presentations before the described project and all of the respondents reported that they had completed at least one poster presentation after the conclusion of the course, with almost half of those having completed two or more posters (Table IV). This was an expected response as students were required to complete a poster presentation for an unrelated second-year course in the curriculum, and many worked on other research projects with faculty and preceptors that they presented at professional meetings. When asked how completing the genetics/pharmacogenomics poster project had affected those subsequent projects, although these percentages decreased to some extent compared to PY1 responses, a majority of PY4 respondents agreed/strongly agreed to the usefulness of this experience for both preparing and presenting future posters projects (77.8% agreed/strongly agreed for preparing, 81.5% agreed/strongly agreed for presenting) (Table V). Only 44.7% of respondents agreed/strongly agreed that they had felt confident in

their presenting skills before the poster project, which is similar to pre-survey PY1 responses for this question. In addition, although a smaller percentage than for PY1 responses, approximately three-quarters (74.1%) of respondents in the follow-up (PY4) survey still agreed/strongly agreed that the poster project had increased their confidence to present future posters (Table V).

Finally, respondents were asked if they would list the genetics/pharmacogenomics poster on their resume/CV as an indicator of their perception of its value. The PY1 students who responded to the pre- and post-survey generally were neutral (37.8% in the pre-survey; 33.3% in the post-survey) or agreed/strongly agreed (48.9% in the pre-survey; 57.8% in the post-survey) that they would include the project on their resume/CV, with the number of students in agreement increasing slightly after completing the project (Table V). Interestingly, more students agreed with this statement in the follow-up (PY4) survey, with 70.4% of students agreeing/strongly agreeing that they included the genetics/pharmacogenomics poster presentation on their CV. Post-hoc analyses were conducted on this dataset to assess whether or not post-graduate plans had any bearing on the value that students placed on this project as a component of their resume/CV and they did not appear to be related.

Discussion

Engaging students with course content beyond typical didactic lectures can improve understanding and learning (Davidson & Katopodis, 2022). An out-of-class poster project assignment that requires students to apply course concepts to a research topic is an example of an engaging teaching approach that does not require a significant amount of class time, which is a concern for pharmaceutical sciences faculty teaching in pharmacy programmes (Kennedy, 2019). Additionally, group projects support cooperative learning as students work together to understand and apply their knowledge (Johnson *et al*., 2014). Cooperative learning improves several outcomes, including higher achievement, more productivity, better processing of information, and more effective interpersonal skills (Johnson & Johnson, 2009). This is most effective when the format of the project requires both interdependence and individual accountability, as well as monitoring by the instructor, all aspects that are incorporated in the poster project described here. Poster projects and presentations have been used to achieve the following educational outcomes: improving scientific communication skills (Hess & Brooks, 1998; Nowak, 1998; Taylor *et al*., 2003; Wheland *et al.,* 2009; Morris *et al*., 2011; Gruss, 2018; Rauschenbach *et al*., 2018), facilitating peer instruction and learning (Hess & Brooks, 1998; Nowak, 1998; Wheland *et al*., 2009), reinforcing course concepts (Morris *et al*., 2011; Gruss, 2018), applying course concepts clinically (Nowak, 1998; Wuller, 2010; Ramsauer, 2011), and fostering an interest in research and research culture (Nowak, 1998; Morris *et al*., 2011; Harirforoosh & Stewart, 2016; Henchey *et al*., 2020). Thus, for a variety of reasons, implementing a poster project into a didactic course in a pharmacy degree programme could be beneficial for students. It can function as a learning tool, enhance depth of understanding, and serve as a stepping-stone to future poster presentations.

There are strictly pedagogical benefits seen with incorporating projects into a university-level course, which can be examined through the context of Bloom's taxonomy. The revised Bloom's taxonomy (RBT) classifies the process of thinking and learning into six distinct levels: remembering, understanding, applying, analysing, evaluating, and creating (Krathwohl, 2002). When considering pharmacy education on a larger scale, the overall objective is to produce competent practitioners, but from a strictly pedagogical point of view, this end goal requires mastery of biological sciences, pharmaceutical sciences, social/administrative sciences, and clinical sciences (Accreditation Council for Pharmacy Education (ACPE), 2015). Within a biological or pharmaceutical science course, mastery of analysing, evaluating, and creating requires deep learning, which is hard to achieve in courses assessed strictly through examination (Cain *et al*., 2022). Projects like the poster project and presentation described in this paper can help bridge the gap between the lower and upper tiers of RBT, which can help students master concepts that are important for their future success as pharmacists.

To assess student perceptions of the poster project's effects on learning, students were surveyed in three specific domains related to course concepts: reinforcement, application, and retention. Reinforcement is an important component of understanding, which makes up a fundamental base for the other two domains, as depicted in Bloom's taxonomy (Krathwohl, 2002). Application and retention, on the other hand, are both essential for students to be able to use their knowledge in their professional pharmacy practice. When surveyed on these topics, the majority of students agreed that the project helped them reinforce, apply, and retain course concepts, in the pre, post, and follow-up surveys. The lowest rates of agreement were in response to the retention question, which exhibited a drop-off between the post-survey and the follow-up survey. This

was somewhat expected based on what is known of memory and the Ebbinghaus forgetting curve, which mathematically depicts how people quantitatively forget information over time (Murre & Dros, 2015). That being said, without a comparator group to assess, it is uncertain if students who learned exclusively through lectures would have better or worse retention than the students who explored the course content through the poster project.

In addition to the questions regarding learning, a smaller percentage of PY4 respondents agreed/strongly agreed with the questions regarding how the poster project may have helped them with future projects, as compared to PY1 responses. Although there are several potential reasons for these differences, in addition to the Ebbinghaus forgetting curve mentioned above, it is important to note that a majority of PY4 respondents still agreed with these questions. The two questions for which responses did not decrease in agreement were regarding using rough drafts for the poster project and whether they included the presentation on their CV. These results support the conclusion that the format of this project works especially well and that the students overall found value in the project for both learning course content and building helpful skills.

One of the logistical challenges of having a poster presentation project is making sure students stay on track throughout the term. The two biggest factors that may affect this are the use of rough drafts and the degree of mentorship the students receive through timely feedback from the instructor. The project described in this paper utilised rough drafts of each section of the poster throughout the term, which were viewed as highly useful by the students both prospectively and retrospectively. At face value, rough drafts are a tool to encourage time management. Looking beyond that, rough drafts are also an opportunity for mentorship, as this allows the instructor to provide individual feedback to each group to enhance their understanding of the course material as it applied to their individual disease state and assess the completeness of their information. Thus, as students progress through a longitudinal project, it is imperative that instructors ensure that they have enough feedback and guidance to succeed.

A piece that comes into play in terms of the feasibility of providing mentorship is group size. Groups must be big enough that providing individualised feedback is possible for the instructor but not so big that they are a logistical nightmare for the students. The project described in this paper used groups of six students, but with a smaller class size or the introduction of additional mentors (additional pharmacy education staff or residents), smaller groups could be possible. In a similar project described by Nowak (1998), groups consisted of three to four students, with other papers describing groups as small as individual students (Gruss, 2018). One technique to reduce the mentorship burden on the pharmacy education staff member, demonstrated by Nowak (1998), was splitting the class into Fall presentations and spring presentations, which was successful but also only possible because the course in question spanned both terms under the same instructor. For courses that only span a single term, this is not an option; thus, adding more mentors or limiting the topics covered by the poster may be possible solutions to reduce group sizes.

Besides pedagogical benefits, incorporating a poster project into the didactic curriculum of a pharmacy programme has other potential benefits for pharmacy students. One of the novel components of this particular project is the unique timing in the curriculum. The majority of poster projects integrated into pharmacy curricula are introduced as upper-level electives or capstone experiences (Wuller, 2010; Ramsauer, 2011; Harirforoosh & Stewart, 2016; Henchey *et al*., 2020). Comparatively, the project described by Nowak (1998) occurs in the second professional year. The project described here occurs in the first professional year and requires students to utilise literature (e.g. Pubmed) and other databases (e.g. PharmGKB), as well as identify accurate, data-supported, and relevant information while investigating the diseases and drugs they are presenting. Furthermore, students learn to prepare, print, and present a professional poster.

Although there are printing and size requirements for this poster project, students are otherwise free to format the content of their posters how they wish. This allows them to be creative in the development of the poster, incorporating new approaches, and learning what works well and does not work well as they present their own poster and view their peers' posters. During the COVID-19 pandemic, students were able to present their posters virtually since they were prepared as PowerPoint files. These aspects are important as, more recently, there has been a switch to more viewer-friendly approaches to poster styling and digital poster presentations with the establishment of distance learning programmes, as well as increased virtual professional meetings and work settings (Persky, 2016; Newsom *et al*., 2021). Completing this process can help students build skills that apply to their future pharmacy education and careers.

In support of this, students with varying levels of experience prior to the project became equally confident in their ability to prepare and present a

poster by the end of the term, which may include skills such as gathering information using databases, creating a digital poster file, presenting a poster, and working in a team. In the pre-survey, the majority of students who had no previous poster presentation experience responded neutrally regarding poster presentation skills, whereas the majority of students who had previous poster presentation experience responded in agreement in the pre-survey. Comparatively, by the time the project was completed, there was no difference in how the two groups remembered their pre-project presentation skill set. From this, it can be inferred that completing a single poster presentation can alter students' perceptions of their own skills and competence, levelling the playing field between students with a single project. This sets the stage for students to pursue similar types of projects on their own and supports the importance of introducing a project like this early in the curriculum for maximum benefit in honing the students' presentation skills and confidence.

One of the major limitations of this study is the scope; just one project within one course in one college of pharmacy was assessed. The primary goal was to evaluate how students perceived the project as a learning tool and thus, the survey questions focused on ties between the project and the course the students were taking, when in fact, the project had the interdisciplinary component of a Pharmacoeconomics poster section evaluating three to four studies focused on the cost-effectiveness of the pharmacological therapy chosen by the team to highlight in their poster. The rough draft for this section is reviewed by the pharmacy outcomes instructor of record, and the grade for that section of the poster is utilised for that course. The purpose of integrating the poster project in this manner was to facilitate an appreciation for each course by connecting them with other pharmaceutical sciences. The value of this component was not gathered based on the questions asked and could be an area of future inquiry. In addition, the survey questions were not validated per se, although they were based to some degree on an analogous published study, and the similarity in results overall between the post and follow-up surveys does support the soundness of the results and conclusions described herein.

Furthermore, while there is a perceived benefit of this project for learning and application of course concepts, this is not an objective measure. However, since this course has never been run without this poster project it is difficult to directly assess the effects of the project on learning outcomes beyond reporting grades earned on the project and for the course overall. Although the survey did assess how the work was split up amongst team members, it did not collect data on each respondent's individual participation. Thus, this aspect was not taken into account in the study. Finally, selection biases may have been introduced through a few possible ways, such as PY4s who had completed research projects on rotation potentially being more inclined to respond to the survey or by providing a bonus or opportunity to win a gift card for respondents. In an effort to overcome at least some of this bias, the informed consent letters indicated that responses were anonymous and would be published in aggregate.

Conclusion

Engaging students with course content through a poster project in a foundational pharmaceutical sciences course in a pharmacy degree programme could be beneficial for students in a variety of ways. A similar project to the one described in this paper could be built into any biological or pharmaceutical science course in a pharmacy degree programme with comparable benefit to the students, but care should be taken to promote interdependent and individual accountability, as well as provide appropriate structure for feedback and mentorship to students.

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References

Accreditation Council for Pharmacy Education (ACPE), (2015). *Accreditation standards and key elements for the professional program in pharmacy leading to the doctor of pharmacy degree: Standards 2016*. https://www.acpe-accredit.org/pdf/Standards2016FINAL.pdf

Brazeau, G. A. (2004). Reflections on active learning in the classroom: Don't walk alone. *American Journal of Pharmaceutical Education*, **68**(2), 52.

Cain, J., Medina M., Romanelli, F., & Persky, A. (2022). Deficiencies of traditional grading systems and recommendations for the future. *American Journal of Pharmaceutical Education*, **86**(7), 8850. https://doi.org/10.5688/ajpe8850

Davidson, C. N., & Katopodis, C. (2022). *The new college classroom*. Harvard University Press. https://doi.org/10.4159/9780674287525

Grey, A. L., Curtis C. W., Young, M. R., & Bryson K. K. (2022). Innovative poster designs: A shift toward visual representation of data. *American Journal of Health-System Pharmacy*, **79**(8), 625–628. https://doi.org/10.1093/ajhp/zxac002

Gruss, A. B. (2018). Communicating microbiology concepts from multiple contexts through poster presentations. *Journal of Microbiology & Biology Education*, **19**(1). https://doi.org/10.1128/jmbe.v19i1.1399

Harirforoosh, S., & Stewart, D. W. (2016). A descriptive investigation of the impact of student research projects arising from elective research courses. *BioMed Central Research Notes*, **9**, 48. https://doi.org/10.1186/s13104-016-1865-1

Henchey, C., Keefe, K., Munger, M. A., & Witt, D. M. (2020). Fostering PharmD student research and quality improvement with mentored projects. *American Journal of Pharmaceutical Education*, **84**(9), ajpe7940. https://doi.org/10.5688/ajpe7940

Hess, G. R., & Brooks, E. N. (1998). The class poster conference as a teaching tool. *Journal of Natural Resources and Life Science Education*, **27**(1), 155–158. https://doi.org/10.2134/jnrlse.1998.0155

Johnson, D. W., & Johnson, R. T. (2009). An educational psychology success story: Social interdependence theory and cooperative learning. *Educational Researcher*, **38**(5), 365–379. https://doi.org/10.3102/0013189X09339057

Johnson, D. W., Johnson, R. T., & Smith, K. A. (2014). Cooperative learning: Improving university instruction by basing practice on validated theory. *Journal on Excellence in College Teaching*, **25**, 85–118.

Kennedy, D. R. (2019). Redesigning a pharmacology course to promote active learning. *American Journal of Pharmaceutical Education*, **83**(5), 6782. https://doi.org/10.5688/ajpe6782

Krathwohl, D. R. (2002). A revision of Bloom's taxonomy: An overview. *Theory into Practice,* **41**(4), 212–218. http://dx.doi.org/10.1207/s15430421tip4104_2

Love, A. G., Dietrich, A., Fitzgerald, J., & Gordon, D. (2014). Integrating collaborative learning inside and outside of the classroom. *Journal on Excellence in College Teaching*, **25**(3&4), 177–196.

Marcinak, R., Paris, M., & Kinney, S. R. M. (2018). Pharmacogenomics educations improves pharmacy student perceptions of their abilities and roles in its use. *American Journal of Pharmaceutical Education*, **82**(9), 6424. https://doi.org/10.5688/ajpe6424

Morris, H.J., Perez I., Llaurado G., & Rodriguez O. (2011). Poster sessions as a learning tool in teaching immunochemical techniques. *Pharmacy Education*, **11**(1), 126-129.

Murre, J. M., & Dros, J. (2015). Replication and analysis of Ebbinghaus' forgetting curve. *PLoS One*, **10**(7), e0120644. https://doi.org/10.1371/journal.pone.0120644

Newsom, L. C., Miller, S. W., & Chesson, M. (2021). Use of digital vs printed posters for teaching and learning in pharmacy education. *American Journal of Pharmaceutical Education*, **85**(6), 8307. https://doi.org/10.5688/ajpe8307

Nowak, D. M. (1998). Term paper/poster session project: Evolution of a learning tool in medicinal chemistry. *American Journal of Pharmaceutical Education*, **62**(1), 83–90. https://doi.org/aj620114.pdf

Persky, A. M. (2016). Scientific posters: A plea from a conference attendee. *American Journal of Pharmaceutical Education*, **80**(10), 162. https://doi.org/10.5688/ajpe8010162

Ramsauer, V. P. (2011). An elective course to engage pharmacy students in research activities. *American Journal of Pharmaceutical Education*, **75**(7), 138. https://doi.org/10.5688/ajpe757138

Rauschenbach, I., Keddis, R., & Davis, D. (2018). Poster development and presentation to improve scientific inquiry and broaden effective scientific communication skills. *Journal of Microbiology & Biology Education*, **19**(1). https://doi.org/10.1128/jmbe.v19i1.1511

Sousa, B. J., & Clark, A. M. (2019). Six insights to make better academic conference posters. *International Journal of Qualitative Methods*, **18**(January-December), 1–4. https://doi.org/10.1177/1609406919862370

Stewart, D. W., Brown, S. D., Clavier, C. W., & Wyatt, J. (2011). Active-learning processes used in US pharmacy education. *American Journal of Pharmaceutical Education*, **75**(4), 68. https://doi.org/10.5688/ajpe75468

Taylor, C. T., Byrd, D. C., Buring, S. M., & Krueger, J. (2003). Integration of pharmacotherapy poster presentations into the advanced practice experience. *Journal of Pharmacy Teaching*, **11**(1). https://www.tandfonline.com/doi/abs/10.3109/J060v11n01_01

Versteeg, M., van Blankenstein, F. M., Putter, H., & Steendijk, P. (2019). Peer instruction improves comprehension and transfer of physiological concepts: A randomized comparison with self-explanation. *Advances in Health Sciences Education*, **24**(1), 151–165. https://doi.org/10.1007/s10459-018-9858-6

Wheland, E. R., O'Neil, T. W., Adler, J. D., & Liszka, K. J. (2009). The poster session: A tool for education, assessment, and recruitment. *Mathematics and Computer Education*, **43**(2), 141.

Wuller, C. A. (2010). A capstone advanced pharmacy practice experience in research. *American Journal of Pharmaceutical Education*, **74**(10), 180. https://doi.org/10.5688/aj7410180

Appendix A: Grading rubric for genetics and genomics posters

Topic:

Evaluator name:

(information provided in the poster and presented should be at the level that is understandable to a College of Pharmacy and Health Sciences professor, but not an expert)

Section 1) Group assessment – Genetics and pharmacogenomics content (pharmacoeconomics content on separate rubric)

	Poor (2.5 pt)	**Fair (5 pts)**	**Good (7.5 pts)**	**Excellent (10 pts)**
1) Description/ Background/ Symptoms *Score*_____	Definition of the genetic disorder is given. No use of scientific terminology in order to further explain the disorder. Medical and behavioral symptoms inadequately described.	Basic description/ definition of genetic disorder. Scientific terminology is used but rarely explained. Medical and behavioral symptoms are listed with few descriptions.	Description of genetic disorder given using scientific terminology that is not explained fully or in simple terms. Most medical and behavioral symptoms are listed as well as descriptions of some.	Full description of genetic disorder. Detailed information written in simple terms in which an audience could understand. Explanation of any scientific terminology. Medical and behavioral symptoms completely and accurately described.
2) Risk factors/ Inheritance/ Testing/ Screening *Score*_____	Recurrence risk and inheritance inadequately described. Lists diagnostic tests but does not explain them.	Mentions risk factors and inheritance without elaborating and explaining them. Gives yes or no explanation for detection of genetic disorder.	Explains specific type of inheritance (dominant, recessive, chromosomal deletion, sex-linked, etc.) Tells briefly how it is detected. Screening methods listed and explained.	Explains specific type of inheritance as well as explains in detail what this type of inheritance is. Explains how it is detected in detail. Screening methods listed and explained.
3) Treatment/ Counsel/ Support *Score*_____	Cursory mention of treatments and support for people with this disorder.	More than one aspect of treatment or care unclear or missing.	Good explanation of treatments and support, but something unclear or missing.	Thorough explanation of treatments and support available for people with this disorder
4) Pharmacology and background of one treatment *Score*_____	Basic description of drug is given. No details are given regarding the background and development of the drug. Mechanism of action and uses inadequately described.	Basic description and background of drug. Minimal details regarding development of the drug. Mechanism of action and uses are listed with few descriptions.	Basic description, background, and development of drug is given, but is not explained fully or in simple terms. Mechanism of action and uses are listed as well as some detailed descriptions.	Full description of drug including background and development. Detailed information written in simple terms in which an audience could understand. Mechanism of action and uses completely and accurately described, including a figure that describes mechanism.
5) Pharmaco-genomics of one treatment *Score*_____	PGx of metabolism, transport, and/or PD inadequately described. Consequences are unclear.	PGx of metabolism, transport, and/or PD briefly described. Consequences are listed without elaborating or explaining them.	PGx of metabolism, transport, and/or PD described fully. Consequences are listed without elaborating or explaining them.	PGx of metabolism, transport, and/or PD described fully. Consequences are listed with full explanation and details.

Section 2) Group assessment – delivery

	Poor (2.5 pt)	Fair (5 pts)	Good (7.5 pts)	Excellent (10 pts)
1) Organisation *Score*_____	No organisation and extremely challenging to understand layout.	Poster is not so easy to read AND the information is disorganised and hard to follow.	Poster is not so easy to read or the information is disorganised and hard to follow.	Poster is easy to read with information presented in a logical manner.
2) Graphics *Score*_____	Minimal graphics with little or no content value.	Poster has few graphics or the graphics are arranged poorly.	Poster includes appropriate graphics that are misplaced or do not help with understanding.	Poster includes appropriate graphics, including images and graphs that attract attention and enhance understanding.
3) Writing mechanics *Score*_____	Three to five typos or grammatical errors. Proof-reading lacking	Three to five typos or grammatical errors.	Two typos or grammatical errors.	No typos or grammatical errors.
4) Sources *Score*_____	No bibliography.			Complete, properly formatted bibliography.

Section 3) Individual assessment rubric

	Needs lots of work and practice (2.5 pts)	Room for improvement (5 pts)	Accomplished (7.5 pts)	Exemplary (10 pts)
Delivery of presentation	Bare minimums have been accomplished. Little understanding about the topic delivered in oral presentation. Could only read poster with no further understanding.	Minimums plus slight extras added. Answered questions and shows some knowledge of the topic.	All information present and complete. Some problems with flow and delivery. Shows more or less some understanding of knowledge - has minor flaws.	Information is well thought out, flows well, all information is complete. Appears to have been practiced, knowledge of disease state, genetics, therapy, and PGx are appropriate.

Presenter section one (Disease description, background, pathophysiology, and symptoms)

Name: Score: _____ / 10

Comments:

Presenter section two (Risk factors, inheritance, screening, diagnostic testing)

Name: Score: _____ / 10

Comments:

Presenter section three (Overview of treatment options (including pharmacological therapies), counselling, and support)

Name: Score: _____ / 10

Comments:

Presenter section four (in-depth pharmacology and background of one treatment option)

Name: Score: _____ / 10

Comments:

Presenter section five (pharmacogenomics of the SAME treatment option)

Name: Score: _____ / 10

Comments: