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Pharmacy Student Engagement in Research through an Elective Course

Sibusiso Dlamini[1]*, Nomvula Khumalo[1], Thandiwe Moyo[1]

[1]Department of Pharmacy Practice and Public Health, School of Pharmacy, University of the Witwatersrand, Johannesburg, South Africa.

***E-mail** ✉ sibusiso.dlamini@gmail.com

Abstract

To incorporate problem-based learning activities into an elective pharmacy research course and evaluate their effects on students' knowledge and confidence in analyzing, designing, and presenting basic research projects related to clinical topics.Interactive learning experiences, such as discussions on study design, creation of conceptual diagrams, project planning, interpretation of results, data assessment, and preparation of presentations, were integrated into the course as team-based activities.At the semester's end, students delivered seminar presentations to classmates and faculty, and they prepared posters for display at professional conferences. Students opting to extend their project into the next semester were required to generate data potentially suitable for manuscript submission to peer-reviewed journals.Student feedback indicated greater appreciation and renewed enthusiasm for examining clinical problems from a broader perspective, along with improved comprehension and self-assurance in applying insights from basic science research data.

Keywords: Research, Elective, Problem-based learning, Scientific writing, Team-based learning

Introduction

Acknowledging pharmacists' vital role in healthcare and their extensive expertise in drug and cellular metabolism, the National Institutes of Health (NIH) created a dedicated website offering details on research initiatives and funding opportunities for pharmacists [1]. The NIH's goal is to boost pharmacist participation in biomedical research, enhancing their input into translational research [1]. Many academic programs have also prioritized research in curricula through specialized research pathways [2] or elective courses [3, 4]. Early, substantive exposure to research is essential for pharmacy graduates considering it as a career path [3].

Beyond advancing pharmacists' role in translational research, such training builds a stronger grasp of biopharmaceuticals and targeted treatments, given the anticipated rise in approvals of biopharmaceutical agents [5]. As many biotechnology-derived drugs are proteins, pharmacists must understand specific handling, storage, and preparation needs. Therefore, studying the biochemical and physiological targets of biopharmaceuticals, plus their manufacturing processes, aids in understanding their clinical applications [6].

Most Doctor of Pharmacy (PharmD) curricula include classes in research methods, biostatistics, evidence evaluation, and drug information [7]. These foundational courses offer skills that can be applied comprehensively in a research elective. The objectives of the course outlined here align with those in Ascione's model for research requirements at the University of Michigan [8], drawn from over 30 years of related coursework experience. The primary goals are to enhance problem-solving abilities and teach scientific analysis methods, while fostering habits for lifelong learning.

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In 2007, 25% of PharmD programs mandated research experience, yet only 3.7% required hands-on data collection and analysis [9]. These findings align with a 2009 survey covering 83% of U.S. pharmacy colleges, concluding that additional research is required to identify optimal approaches for teaching research skills to PharmD students [10]. The elective course presented here employs problem-based learning methods to strengthen problem-solving and project management skills, focusing on effective data gathering and evaluation. The primary aim of this work was to describe and assess an elective course structure that offers students authentic involvement in a research team generating novel contributions to a specific area.

Design

This research elective allowed students to gain insights into laboratory-based research via independent work on a chosen project under faculty mentorship, covering conceptualization, planning, and implementation. Each phase adhered to Bloom's taxonomy of educational objectives [11]. Upon completion, students were anticipated to:

1. Conduct efficient literature searches and critically appraise existing publications.
2. Develop a hypothesis grounded in existing knowledge of a particular subject.
3. Pinpoint key questions required to test the hypothesis.
4. Suggest an experimental approach using accessible methods.
5. Gather and interpret data, monitoring advancement toward hypothesis validation.
6. Assess the importance of findings and potential clinical implications.
7. Prepare and deliver a presentation tailored to a defined audience.

The research elective was available to second- and third-year PharmD students and could be taken for 2, 3, or 4 credit hours. Faculty members actively involved in ongoing research projects provided a varying number of positions in basic or clinical research, depending on the scope and specific questions addressed by their studies. Laboratory facilities and funding for supplies were supported through university startup packages for faculty and/or external grants. Collaborations with other university departments were also utilized when needed to fulfill particular project demands.

Students were advised to make informal visits to faculty laboratories to observe ongoing work and assess whether the research area aligned with their interests prior to enrollment. In the author's cancer-focused laboratory, interested students typically fell into three categories: those taking the elective for the first time, those returning for a second project by re-enrolling, and visiting students considering potential involvement in the research team. Prior to the start of each semester, individual meetings were arranged with prospective students to outline active projects. These discussions clearly explained the knowledge gaps the projects aimed to address, their long-term objectives, and the clinical significance of the work. At the time of this study, two projects were active in the author's laboratory. Project 1 focused on examining human epidermal growth factor receptor 2 (HER2) cell signaling pathways in carcinogenesis **(Figure 1)**. Its long-term objective was to uncover mechanisms linked to the early phases of HER2-driven cancers. The second project aimed to evaluate novel plant-derived compounds with ethnobotanical relevance in cancer treatment. These purified and characterized compounds were screened against a panel of cancer cell lines using protocols established by the NIH/National Cancer Institute Developmental Therapeutics Program [12]. Identifying and validating new antineoplastic agents represented a key element of translational research, thereby aligning with one of the core goals of this initiative.

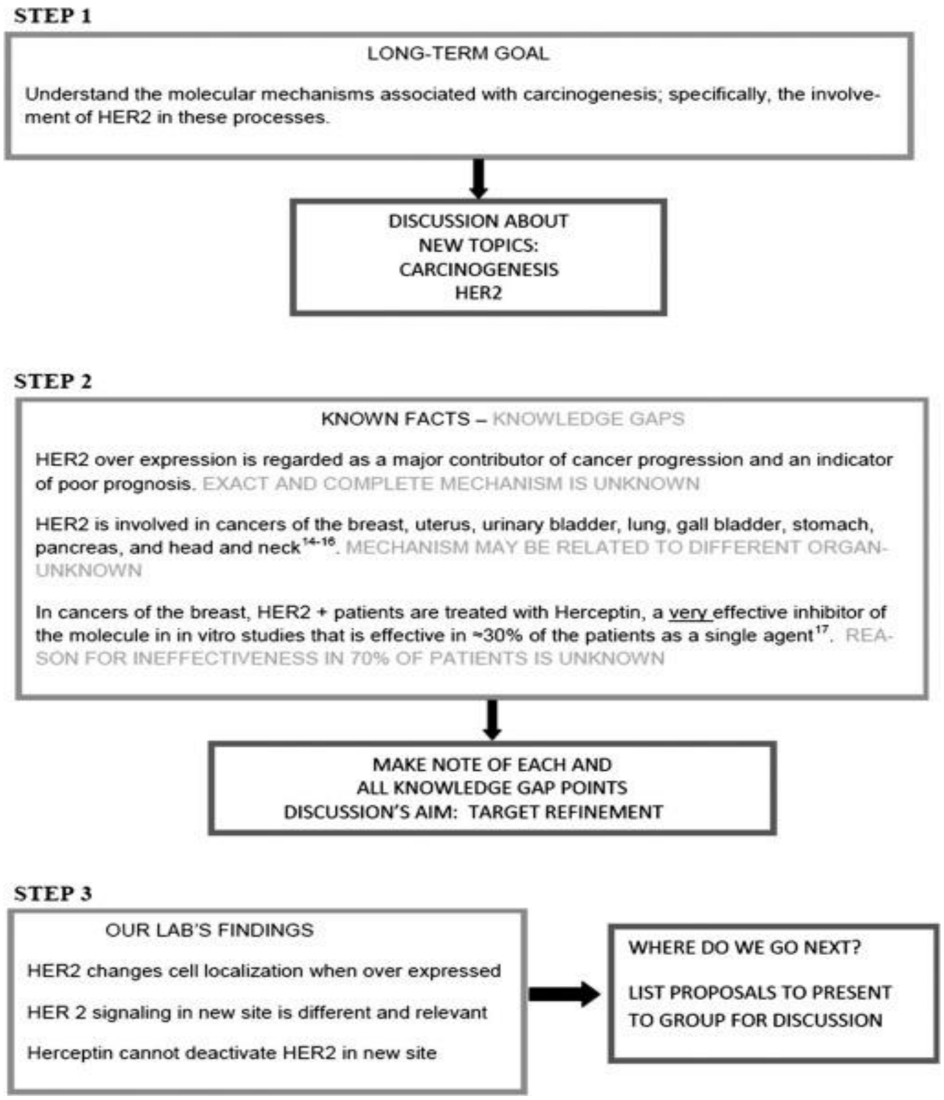

Figure 1. Design for a project included as a research option in an elective course to encourage pharmacy students involvement in research activities.

Students received an example of introductory information and hypothesis development for each project, as shown for project 1 in **Figure 1**. This approach aimed to clearly establish the clinical relevance of each project before delving into specific techniques and to provide students with the foundational information needed to make an informed project choice. Initial meetings focused on reviewing background literature, examining work from other laboratories, and considering recent findings from our own research initiatives. These interactive sessions were intended to engage students in evaluating current research and assessing potential new projects, with the goal of identifying knowledge gaps or unmet research needs. Projects were designed to have clinical significance, meaning that even basic research hypotheses were expected to have potential clinical applications.

Research projects were carried out according to the scientific method. At the start of each meeting, teams—typically consisting of 2 to 4 students—provided updates on the progress of their experiments, promoting ongoing monitoring of project development. This was particularly important since some laboratory work occasionally required completion by faculty mentors or technicians rather than the students themselves.

Various strategies were implemented to encourage active student participation. For instance, students were invited to "share the whiteboard," where all team members contributed to discussions, often by drawing diagrams or flowcharts to clarify ideas or troubleshoot protocols.

Teams were also encouraged to communicate continuously via email and texting, reinforcing the value of exchanging ideas rather than dismissing questions, a critical part of the problem-solving process. Maintaining a laboratory notebook was mandatory for documenting progress.

Under faculty mentorship, students collaboratively defined and selected research questions that could test their hypotheses. Open team discussions were crucial in refining the project aims into actionable guidance points. These aims were designed to be clear and achievable, considering the techniques and expertise available to the team. Expanding expertise through consultation or collaboration with other university researchers was encouraged to strengthen project design. After defining the specific aims, students chose a project aligned with their interests and maintained close communication with peers working on the same project.

Students were provided with general techniques for each experimental step. Protocols were collectively designed and discussed using drawings and flowcharts, with a focus on understanding the underlying principles of each technique to foster comprehension and facilitate suggestions for protocol modifications. This approach created a dynamic learning environment where students' confidence grew through active participation in experimental design and team-based problem solving.

Students were also instructed on data analysis parameters, including the use of positive and negative controls within their experimental designs. Teams selected appropriate controls based on prior work or published studies from other laboratories. Data collection and preparation for qualitative or quantitative analysis—such as calculating standard deviations, generating graphs with error bars, or measuring fluorescence intensity for molecular expression analysis—was conducted using suitable software and equipment under close supervision from faculty mentors.

Evaluation and assessment

Students were expected to provide a draft of their seminar presentation to the faculty advisor at least three weeks before the semester concluded. Drafts could be prepared as part of a team effort, focusing on novel techniques, experimental designs, or unique research findings. While each student was assigned a specific portion of the presentation, the group collectively ensured that the final product flowed smoothly and cohesively.

Although the ideal scenario was for every student to independently create a poster presentation, this was often impractical due to the limited high-quality data collected by first-time elective participants. To address this, teams combined their individual data into a single collaborative poster, still allowing students to learn the structure, content, and professional standards expected in a poster under faculty mentorship.

Each team was responsible for identifying an appropriate scientific or professional forum to present their findings. Potential venues were evaluated collectively, and students drafted abstracts, which were reviewed and refined with guidance from their faculty mentor before submission. Teams also prepared preliminary posters and participated in internal university sessions, which helped them refine presentation skills and clarify uncertainties about their research. The finalized posters were subsequently presented at national conferences. **Table 1** provides an overview of student research activities during 2010.

Table 1. Pharmacy students' productivity in an elective course to encourage student research activities

Activity in 2010	HER2 Team, Project 1	New Compounds Team, Project 2
Internal meetings/poster presentations	2	2
National meetings/abstract submissions	2	2
National meetings/abstract acceptances	1	5
Publications	1	-

Abbreviations: HER2= human epidermal growth factor receptor 2

Students continuing projects from the prior semester **(Table 2)** and possessing enough data to draft a manuscript for potential journal submission were given the choice to have their faculty mentor review their manuscript draft instead of delivering a seminar presentation. This alternative enabled students to engage in manuscript preparation while also fostering critical-thinking and analytical skills.

Table 2. Continued student participation on research projects in an elective course to encourage pharmacy students' research activity

	Spring 2010	Summer 2010	Fall 2010	Spring 2011
Returning students from previous semester, %	33.3	33.3	50.0	57.0
Returning students, Team 1, %	33.3	–	16.6	14.2
Returning students, Team 2, %	–	33.3	33.3	42.8

The college conducted a summative evaluation to assess whether the course successfully offered opportunities in background analysis, overall project planning, scientific writing, problem-solving, and other critical thinking skills **(Table 3)**. In 2010, seven students took part in this elective, and all completed the survey. Regarding the chance to analyze background information, all respondents either strongly agreed or agreed (85.7' and 14.3', respectively) **(Table 2).** Every student strongly agreed that the course strengthened their project planning capabilities, while most either strongly agreed or agreed that it provided training in scientific writing (55.1' and 42.9', respectively). Additionally, a majority strongly agreed or agreed that the course helped enhance their problem-solving skills (71.0' and 14.3', respectively).

Table 3. Pharmacy students' feedback on a research elective course (N = 7)

Course Aspect	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Mean Rating (SD)[a]
Enhances my skills in analyzing background information	6	1	0	0	0	4.9
Improves my ability to plan projects effectively	7	0	0	0	0	5
Provides an opportunity to apply classroom theoretical knowledge	6	1	0	0	0	4.9
Broadens my knowledge in relevant areas [b]	6	0	0	0	0	5
Offers instruction in scientific writing	4	3	0	0	0	4.6
Prepares me to present research confidently at scientific meetings	5	2	0	0	0	4.7
Supplies adequate chances to develop problem-solving skills [b]	5	1	0	0	0	4.8
Provides hands-on, practical experience in research project design	7	0				5

[a] The median and mode for all items were 5.

[b] Only 6 of the 7 students responded to this item.

Seven abstracts were submitted for peer review, with six ultimately accepted for poster presentations at national scientific meetings. Reviewers provided critiques focused on methodology, focus, and presentation, which guided students in refining their posters. One abstract was not accepted because its data were more appropriate for a tumor biology-focused conference, offering the students a valuable lesson in selecting appropriate venues and promoting discussion on effective abstract writing. In addition, a manuscript co-authored by two students was published in a peer-reviewed journal in 2010, while two additional manuscripts remained under review.

Results and Discussion

Translational research plays a pivotal role in moving laboratory discoveries into clinical practice efficiently. Effective communication and feedback between basic scientists and healthcare professionals underpin the bench-to-bedside model. Allowing health-science students to engage with, analyze, and discuss fundamental research projects is vital for developing translational research infrastructure, as it enhances their confidence in connecting these findings to related clinical fields.

Students reported that the course provided practical opportunities to develop essential research skills, from initial project planning through data analysis. They completed sequential activities that enabled them to either present their findings at conferences or submit their work to peer-reviewed journals. As shown in **Table 1**, having their work peer-reviewed served as a meaningful measure of their progress.

Although conference funding was not guaranteed, the college maintains a dedicated fund for student travel. When available, travel support requests submitted to the Office of Student Affairs were typically approved.

Collaborative problem-solving in the course created an interactive learning environment in which students evaluated options collectively. Comfort in presenting research was used as one measure of the success of these discussions. Summative evaluations revealed that all students either strongly agreed or agreed that the course gave them the foundation needed to present their research confidently.

The course also aimed to ensure that skills acquired were integrated into students' broader knowledge rather than being isolated by the specific research topic. Summative evaluations indicated that all students strongly agreed (85.7') or agreed (14.3') that the course expanded their knowledge base and allowed application of theoretical classroom concepts, demonstrating successful integration of new skills and enhancement of problem-solving abilities.

Time constraints and limited experience with hands-on research are common challenges for pharmacy students [3]. To address these, laboratory sessions were flexible, techniques were introduced individually, and applications were reviewed repeatedly. Students returning for a second semester were expected to mentor new participants, with faculty supervision to ensure quality guidance.

Enrollment challenges mirrored findings from Surratt et al., including lack of awareness about the research elective and time limitations within students' schedules [13]. To increase awareness, Gatton College of Pharmacy participated in a university-wide research forum for graduate and undergraduate students in the Appalachian region. Flexible scheduling was provided to accommodate the demanding curriculum, allowing students to manage experiments efficiently while incentivizing better time management. Informal participation was encouraged to let prospective students explore the research experience prior to formal enrollment.

Conclusion

Feedback indicated that students gained a broader perspective in analyzing clinical questions and increased confidence in interpreting data derived from basic research. The proportion of students continuing with follow-up projects ranged from 33' to 57'. Alongside positive feedback, these outcomes highlight the importance of hands-on research experiences in fostering student confidence and providing a meaningful engagement with scientific investigation.

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