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Introducing a Professional Development Skill Building Platform Into a Biomedical Sciences Graduate Program Curriculum in Pharmacology

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Correspondence: Elizabeth S. Yeh (esyeh@iu.edu)**Received:** 13 January 2025 | **Revised:** 16 June 2025 | **Accepted:** 6 July 2025**Keywords:** biomedical | career | curriculum | graduate | pharmacology | professional development

ABSTRACT

Biomedical graduate students are training for diverse careers that extend beyond the academic environment. However, many graduate programs are designed to train individuals in a specialized scientific field, and the main research project of trainees is often narrow in scope, with a focus on a specific topic of intense study. To be effective in the scientific workforce, trainees need skills beyond what is learned through bench science and critical thinking that supports scientific discovery. Generalizing critical thinking to improve interpersonal interactions through communication, emotional intelligence, and an understanding of the environment in shaping career development is similarly crucial for professional success. To prepare trainees beyond the typical focused scientific project and training, this manuscript describes the process and outcomes for a graduate program in pharmacology that piloted a course containing intentionally designed curriculum to reach beyond the traditional scope of training and provide skills-based professional and career development training. Here, we share the course design, feedback from students across 5 years, and lessons learned about implementing this type of strategy. Each year, students were provided short voluntary surveys to complete, and the surveys were used to determine whether students thought the material was relevant and helped them to be better scientists. The surveys were also used to create the course syllabus each semester in a semi-on-demand fashion. Overall, data suggest that the students perceived that the course is beneficial and that it is challenging to address all needs at all times.

1 | Introduction

Attrition from academia in biomedical science fields upon completion of the PhD degree is an ongoing trend [1]. Many biomedical training programs, including those in pharmacology, continue to train students predominantly for academic careers despite this shifting landscape [1, 2]. Prior work indicates that doctoral trainees in biomedical sciences that transition to non-academic careers perceive there is a gap in certain types of transferable skills including working with others, time management,

and career planning [3]. However, there is an increasing awareness of the need to better prepare graduate biomedical science trainees for the broader workforce beyond academia [4].

A prior study looked at career outcomes of >1400 biomedical sciences PhDs who graduated between 1997 and 2021 and found that >50% of students changed their career goal between the time of matriculation and the time of defense [5]. Students were provided entry and exit surveys to assess career interests and how these interests shifted over time. From the time of

Abbreviations: A, agree; D, disagree; IBMG, Indiana BioMedical Gateway; IUSM, Indiana University School of Medicine; N, neither agree nor disagree; SA, strongly agree; SD, strongly disagree.

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matriculation to the time of defense, there was a decline in the number of students interested in pursuing academic careers, and students indicated that this shift was due to negative perceptions about academia. Consistent with this, there was also a shift in interest toward industry careers between the time students matriculated and when they completed their degrees. In line with the observations from this study, the NSF Survey of Earned Doctorates indicates that the number of biological and biomedical sciences doctorate recipients in 2021 who were employed in industry or business was greater than the number employed in either academe or in a postdoc position [6].

Evidence suggests there are key gaps in graduate education that create challenges for post-graduation career placement, including lack of knowledge about career options and insufficient professional skills to navigate career transitions [7]. Implementation of initiatives that address these gaps, such as coursework that focuses on professional skills development, provides biomedical PhD students with the context needed to prepare for navigating career transitions post-degree completion [8–10]. Therefore, as a PhD degree-granting program in the biomedical sciences, we set out to find methods to support our graduate trainees in the shifting career landscape by providing transferable skills that could be used in both academic and non-academic workforce settings.

To address these challenges, we introduced a professional development skill building platform into our graduate program curriculum. The goal was to find practical ways of preparing trainees beyond the typical focused scientific project and training. The material in the course provided students with tangible professional skills that can be generalized into the work environment. The structure of the sessions was intentionally created to be varied using a mixed learning strategy, which uses a hybrid or blended approach to enhance learning. Adapting courses using a hybrid approach that contains web-based and virtual platforms has been shown to be successful within the biomedical learning environment [11–13]. Our adaptation of this approach included providing students with self-directed activities and having experts join the class through virtual platforms to interact with students. Several elements of the course design were aimed at delivering material in a digestible and context-relevant manner where students could apply the skills that they learned in their immediate environment as well as maintain these skills for future application after entering the workforce. The course contained several types of learning components that included workshops, seminars, student-led sessions, and didactic learning. These different components provided students with face-to-face interactions that promoted engagement through discussion and knowledge sharing. Experts in various career positions reflective of the broad range of jobs available to students post-graduation interacted with students mainly through virtual classroom engagement allowing for interactions beyond local industry, although in-person career seminar sessions with local industry experts were also represented.

Here, we report the students' perceptions of the course and lessons learned about implementing this type of strategy. Based on our assessment, we conclude that overall student perception of the course was positive, and we further discuss positive aspects of the course as well as challenges and limitations.

2 | Methods

2.1 | Study Participants

Students were part of the Indiana University School of Medicine (IUSM) pharmacology graduate training program. Students initially applied through the Indiana BioMedical Gateway (IBMG) umbrella program at IUSM. Typically, in year two of their studies, students that entered through the umbrella admissions system transition to a program track of their choice. Detailed demographics of the study participants are not provided to maintain privacy for participants. All students in the pharmacology training program are required to take four semesters of a student seminar course, which are usually completed within years two and three of their studies. Course enrollment compared to the number of total students in the program is shown in Figure 1. Across the 5-year span of evaluation, there were between 17 and 24 students in the pharmacology training program in any 1 year for an average of 19 students per year. Of those students, ~12 students were enrolled each year in the course. Students enrolled in the course were asked to voluntarily complete a survey at the end of the calendar year (i.e., fall semester). Students were surveyed four times across a 5-year period. This study was evaluated by the Indiana University Human Subjects Office (IRB #24403) and was considered non-human subjects research due to the lack of access to identifiable data.

2.2 | Development of Curriculum

The original concept for the student seminar course was to have students present in a student-led research in progress seminar series and student-led journal clubs. In response to feedback from pharmacology program students, the course was redesigned to increase awareness of the changing professional and career-related needs of the students. The new course was launched in the fall semester of 2020 and has now been implemented for 5 academic years. While a major focus of this course is still student seminar presentations and evaluation of scientific presentation skills by faculty, several new aspects were introduced to this course. Career development sessions were offered where experts are invited to give a presentation and engage in a question-and-answer session

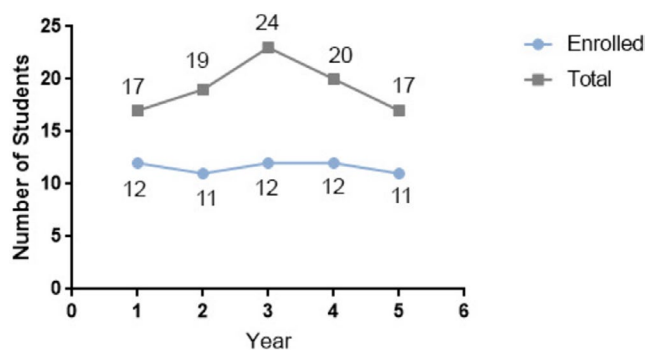


FIGURE 1 | Total number of students in the pharmacology graduate program in gray. Total number of pharmacology graduate students enrolled in the class each year for the first 5 years of the course from academic year 2020/2021 until 2024/2025.

TABLE 1 | Sample curriculum with list of topics in specific areas.

Examples of careers covered by invited speakers

- Research Core Director^a
- Scientific Editor
- Research/Principal Scientist, Industry
- Program Director

Examples of professional development workshops

- Conflict resolution
- Science communication
- Emotional Intelligence
- Peer mentoring/mentor-mentee relationships

Examples of scientific skill building topics

- How to respond to reviewer comments
- Building a hypothesis and developing graduate fellowships
- Use of online datasets
- Data presentation and use of analysis software

^aResearch Core Director refers to an individual who oversees a facility that provides a centralized research service for investigators at a university.

with trainees. Where possible, alumni were invited to give these presentations. Example careers include journal editor, program director, patent agent, industry experts, and others. These interactions have provided a networking platform for the students. A subset of class sessions was focused on scientific skills-based learning to provide students with practical tools for success. These sessions included topics like navigating productivity software, making figures, and a “data club” where students discuss how to navigate using scientific techniques. The data club sessions were typically led by senior graduate students, postdoctoral scholars, and core directors or experts who provided technical discussion on specific scientific techniques. Finally, professional development workshops were provided where topics including science communication, leadership skills, implicit bias, imposter syndrome, wellness, and other related topics were discussed. A sample of the curriculum is provided in Table 1.

2.3 | Evaluation Methods and Statistical Analysis

Students enrolled in the course were provided a voluntary survey at the end of each fall semester of 2020, 2021, 2023, and 2024. The surveys were used to determine whether students thought the material was relevant and helped them to be better scientists. The surveys were also used to create the course syllabus each semester in a semi-on-demand fashion. Survey response rate of enrolled students is shown in Figure 2. The survey consisted of two multiple choice questions (referred to as Q1 and Q2) and four free response open-ended questions (referred to as Q3–Q6). Multiple choice responses consisted of strongly agree (SA), agree (A), neither agree nor disagree (N), disagree (D), or strongly disagree (SD). Survey results were analyzed using descriptive methods. For Q1 and Q2, results were averaged across all surveys and SA/A responses were compared to the N and D/SD responses. Kruskal Wallis one-way ANOVA analysis with Dunn’s post hoc test was performed for Q1 and

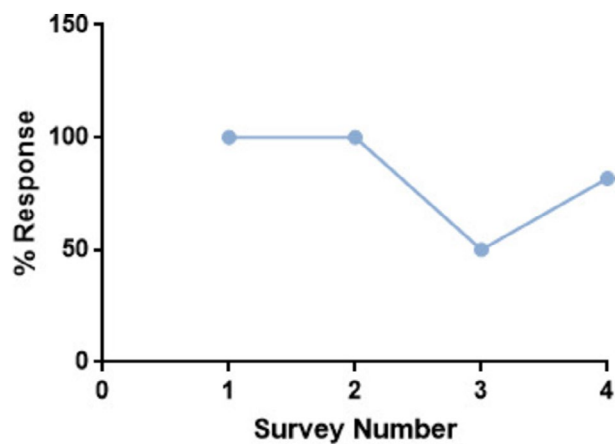


FIGURE 2 | Survey response rate for each of the four surveys provided. Each point represents the % of students of the total students enrolled in the representative year that responded to the survey.

Q2 using GraphPad Prism software (v7). A p -value < 0.05 was considered significant. Free response data from Q3 to Q6 were analyzed using a modified version of the Framework Method of qualitative data analysis [14].

3 | Results

Students enrolled in the course were asked to voluntarily fill out a survey containing two multiple choice questions and four free response open-ended questions (Table 2). The same questions were asked each instance the students were surveyed. Responses were tabulated and compared across all surveys.

For Q1, students were asked to respond whether “the content of the class was relevant to me.” All students (i.e., 100%) responded that the content of the course was relevant, and this response did not change over time. No students ever responded N or D/SD. Results are shown in Figure 3A.

For Q2, students were asked to respond whether “the content of the class helps me to be a better scientist.” For this question, the majority of students (88.5%) responded A/SA while 11.5% responded N. No students responded D/SD across all surveys. Results are shown in Figure 3B.

For Q3–6, responses were categorized into themes. Table 3 shows categories, codes, and representative quotes of positive and negative feedback. Overall, responses were predominantly related to either class content or structure. The majority of comments about class content were positive. Seminars covering career-related topics received consistently positive feedback. Responses also indicated that learning about others’ research was a positive feature of the course content. Negative feedback about course content was infrequent and focused mainly on the relevance of a particular topic. In some instances, survey responses would give both positive and negative responses about the relevance of the same topic, suggesting that for some students a topic was considered relevant but for other students it was not. This discrepancy in response is not surprising given the variety of scientific and professional skill interests represented by the students in class overall.

Comments about class structure varied but again were largely positive. Many positive comments were received about the mixed learning strategy, which integrated self-directed work, speakers interacting with students virtually and in-person, group discussion, and traditional lecture style components. Students enjoyed having a mixture of workshops, speakers, and student presentations. This strategy provided an environment that supported participation. The classroom environment and approach to learning, which was heavily centered on student discussion and engagement during interactive workshops, was also received positively. While students appreciated that the opportunity was provided for all students to participate, negative feedback around participation centered on the public feel of the platform or difficulty navigating time management. This response is understandable given that students may come from a variety of backgrounds and cultures with varying lab-specific responsibilities and demands.

TABLE 2 | Survey questions.

Q1. The content of the class was relevant to me

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

Q2. The content of the class helps me to be a better scientist

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

Q3. What did you like about the class? (open ended)

Q4. What did you dislike about the class? (open ended)

Q5. Is there content for the class you would like to suggest? (open ended)

Q6. Additional comments and suggestions. (open ended)

4 | Discussion

4.1 | Practical Implementation

The goal of creating such a course was to move toward finding practical ways of preparing trainees beyond the typical focused scientific project and training. The professional development workshops were designed to maximize class participation, which the data from open-ended survey responses showed was well received by the students (~16% of survey respondents provided positive feedback). Qualitative responses to open-ended survey responses also indicated that the course instructor or session leads would need to be skilled at navigating difficult conversations in order for lessons to be effective (~5% of survey respondents provided this feedback). Furthermore, survey responses indicated that students felt like their input was taken seriously and that they were contributing through discussion (~13% of responses reflected this input). Responses also indicated that students would have liked for their classmates to contribute more (~18% of responses reflected this input); however, participation in all sessions was not made mandatory to support potential differences in cultural backgrounds and attitudes toward sharing experiences across students. The course implemented a mixed or blended learning approach, which studies have demonstrated to support class engagement [15, 16]. In general, it was perceived through the qualitative feedback from open-ended survey questions that the method of instructional delivery was viewed as aiming to be highly engaging for all participants.

4.2 | Generalizability

Although the original course design was targeted at the PhD level graduate trainees, the content of the course was found to be more broadly applicable to other trainee populations within the local environment. In 2022, the course was opened to master's students and postdoctoral researchers. Although these individuals were not included in the survey analysis, many joined the discussion and showed engagement throughout the sessions. A consideration is that not all material may be applicable at all times across each level of training. For example, master's level students may not be engaged in discussion related to preparing graduate fellowships, whereas postdocs may find the discussion

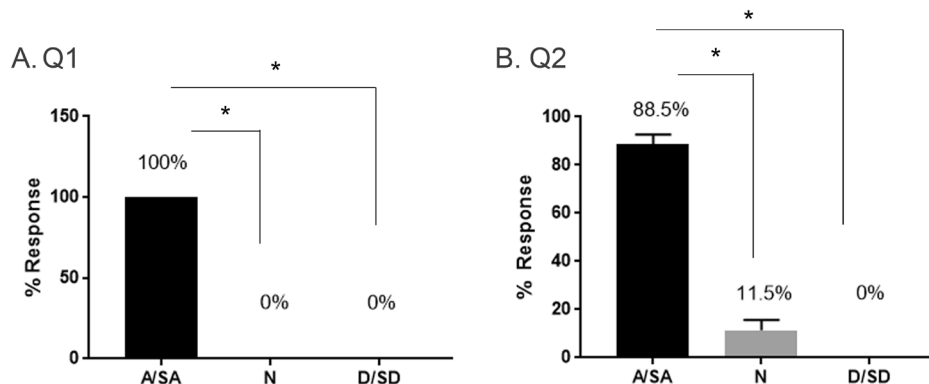


FIGURE 3 | Survey responses for (A) Q1—the content of the class was relevant to me. (B) Q2—the content of the class helps me to be a better scientist. Kruskal-Wallis-Test indicates a $p < 0.01$ for (A and B).

TABLE 3 | Thematic analysis. N represents the total number of responses across all 4 surveys.

Categories	Codes	Representative Q3 feedback	Representative Q4 feedback
Content	Career focused seminars	I really liked the visiting speakers and getting to talk with professionals from different backgrounds and experiences. <i>N</i> =6	I would have more career talks. <i>N</i> =1
	Professional development	I can appreciate that the department recognizes that students come from different backgrounds and that not everyone has been exposed to interpersonal skills that will help them be successful. <i>N</i> =6	Some of the beginning lectures felt repetitive and like more common sense. Some topics revisited might not apply to all the students. <i>N</i> =1
	Research seminars	The student presentations were really well done, they helped all of us get to know what everyone is doing in the lab and to get good feedback from the students. I think that feedback from the students is the best thing you can get from something like this as the students may not know very much about the topic at hand and this will allow the presenter to see what they need to explain more clearly. <i>N</i> =8	
	Broad perspectives	I appreciate the different speakers that have been invited in terms of background and career paths. Lots of different perspectives and options for future, lots of great advice about the future. <i>N</i> =3	
	Relevance	The relevant discussions about general day to day life in grad school, as well as the organization and structure of the class. <i>N</i> =5	Sometimes I find the topics not super relevant, at least to this stage in our careers. <i>N</i> =4
	Variety	A wide variety of topics that change year to year. <i>N</i> =7	Case studies may be interesting to discuss. <i>N</i> =2
Structure	Mixed learning strategy	Content and formatting containing a mixture of lecture styles and informal sessions. <i>N</i> =2	Although I liked the formatting of the sessions where it was a group discussion, there were times where I felt like if we had smaller group discussions so that everyone got to voice their perspectives and then reconvened with the bigger group might be helpful. <i>N</i> =2
	Instructor	The professor is very welcoming and handles difficult conversations so well. <i>N</i> =2	
	Participation	The opportunity that was provided for all student to participated and feel my comments were taken seriously. <i>N</i> =5	The platform can feel a little public to have these discussions (which may or may not be a good thing), and does not always include everyone's input. <i>N</i> =7
	Skills based learning	The class provided a platform to engage in discussions that are important, but otherwise may not be easy to come by. I felt there was a sense of personal growth that came from these discussions. <i>N</i> =4	
	Sense of being part of a program or group	I liked that the class was very interactive and allowed everyone to share their ideas or opinions while staying professional and understanding. <i>N</i> =6	

useful because the content could be applicable to postdoctoral level fellowship applications.

Because the material being delivered is varied and in general widely applicable, this type of content and mixed learning strategy could be implemented at other learning institutions that support similar types of training, as well as other areas of research. Mixed learning styles are aimed at widening participation and providing students with different outlets for learning [16]. The structure of the class borrows from the concept of learning through participation (LTP), which is a teaching strategy that aims to engage students to be part of the learning process [17]. This type of learning takes into account students' sense of self within the group and/or field [18]. However, it is difficult to assess whether students transfer learned skills into practical application [19]. Even though the local training population in this example is pharmacology focused, the learning strategies described have potential application across other areas within the biomedical sciences and beyond. Professional skills such as understanding emotional intelligence and how to navigate difficult conversations are widely applicable to the training and workforce environment. Further investigation is required to address how to best assess whether this type of strategy leads to measurable outcomes [19].

4.3 | Lessons Learned

The semi-on-demand nature of the course is beneficial but difficult to navigate because each year when new students entered the graduate program, similar needs and interests in topics were expressed as in prior years. Students who are in later years of the program were sometimes less enthusiastic about covering material they had already experienced, despite efforts to vary the discussion from year to year. The course was designed in this manner to allow senior graduate students to provide their experiences to more novice students; however, survey results indicated that a subset of students found revisiting topics to be repetitive (reflects ~3% of responses).

Due to the varied scientific and career interests of the students, some participants found that certain sessions were not relevant to their interests or needs (~11% of survey responses). For example, where sometimes students requested career speakers in areas tangential to what would be considered a traditional scientific career path, others thought these types of speakers were not relevant.

Although not shown in the set of representative feedback in Table 3, students acknowledged in Q6 (see Table 2) that they understood it requires a lot of planning to put together the course schedule each semester. Despite the challenges discussed here, the course appears to have been well received, and it is understood that it is likely impossible to satisfy the wants and interests of 100% of students at all times in this type of setting. Given the overwhelmingly positive responses from Q1 to Q2 (see Figure 3), the course appears to be well received by students who participated.

5 | Conclusions

Overall findings from our analysis suggest that there was strong agreement that the material in the course was relevant

to students and helped them be better scientists. Qualitative feedback indicated that the students found that the course is beneficial and that it is challenging to address all needs at all times. The mixed learning strategy was perceived to help with keeping students engaged even if every student did not think the material benefited them individually. Important features of the course that will support other institutions or programs to also implement such a curriculum include choosing an instructor that is skilled in navigating difficult conversations, choosing topics and speakers that are relevant to the needs of the local student population, and being cognizant of the different cultural needs and attitudes of the students being trained.

Author Contributions

E.S.Y. designed and implemented the new course curriculum, performed the analysis, wrote, and edited the manuscript. J.D.R. wrote and edited the manuscript.

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Ethics Statement

This study was reviewed by the Indiana University School of Medicine's Institutional Review Board under IRB #24403 and was considered non-human subjects research by the review committee due to the lack of access to identifiable data.

Consent

The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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