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Bridging the gap: the OPTIONS program as a model for integrating career development into biomedical PhD training

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The OPTIONS program employs an innovative approach to integrating career readiness into the foundation of biomedical doctoral education. Designed to address the growing need for diverse career pathways beyond academic roles, this three-phase program provides structured opportunities for PhD students to explore career interests, develop transferable skills, and participate in experiential learning opportunities prior to graduating. Over the past 6 years, the program has experienced substantial growth, currently supporting over 300 doctoral students and with ~50 alumni who have transitioned into careers across academia, industry, government, and other sectors. Preliminary findings suggest that participating in the OPTIONS program improves students' ability to articulate how their graduate training translates to career opportunities and enhances their awareness of actionable steps to develop career-related skills. By embedding career development into doctoral education and addressing evolving workforce demands, OPTIONS represents a scalable model for equipping graduates to thrive in today's dynamic and multidisciplinary professional landscape.

KEYWORDS

biomedical education, experiential learning, career exploration, self-reflection, PhD curriculum

Introduction

Traditional academic training for biomedical doctoral students has long focused on preparing graduates for tenure-track faculty roles. However, fewer than 25% of graduates enter this career path (NSF, 2020), revealing a gap between training and career outcomes. With the number of available faculty positions remaining limited annually (Lange and Olejniczak, 2023) and the job market continuing to evolve, doctoral programs must expand their scope to prepare students for diverse careers in industry, government, and beyond. Addressing these challenges requires equipping PhD students not only with advanced research skills but also with the confidence and competencies needed to navigate a broader biomedical workforce.

Recognizing this need, the National Institutes of Health (NIH) Advisory Committee to the Director (ACD) convened a Biomedical Workforce Working Group in 2012 to propose solutions. The group's recommendations emphasized modernizing graduate training to reflect the realities of today's workforce (NIH, 2012). In response, the National Institute of General Medical Sciences (NIGMS) launched an initiative to promote career development innovations. NIGMS Predoctoral Training Grant (T32) programs were invited to apply for supplemental funding to expand career exploration and skill development resources. These efforts aimed to

broaden support for diverse career paths and better prepare students for success both within and beyond academia (NIH, 2016).

Aligned with this initiative, Johns Hopkins University (JHU) developed the Opportunities for Professional Training in Occupations for Scientists (OPTIONS) program. Originally funded through an NIGMS supplemental grant, OPTIONS has since received sustained support from JHU, reflecting the university's commitment to enhancing career readiness for PhD students (Johns Hopkins University, 2024). The OPTIONS program offers a structured, three-phase career development curriculum designed to address students' evolving career needs throughout their doctoral training. Each phase incorporates self-reflection and skill-building, culminating in Phase 3, which emphasizes experiential learning. This final phase encourages students to gain hands-on experience, develop essential competencies, and expand their professional network before graduating. This structure ensures that students engage with career planning as a dynamic, iterative process rather than a one-time decision.

Launched in 2017 as a pilot initiative, OPTIONS has continually evolved to meet shifting student needs and workforce demands. Initially designed for in-person delivery, the program adapted during the COVID-19 pandemic to include virtual formats, expanding access to guest speakers, recorded content, and external resources such as panel discussions, webinars, and networking events focused on career and professional development. In 2022, OPTIONS further enhanced its accessibility and impact by integrating a self-reporting and reflection system into the university's new learning management system (LMS), Canvas. This update centralized program resources and introduced tools for tracking student engagement, allowing participants to log activities, complete reflections, and access materials more easily.

This paper evaluates the early impact of the OPTIONS program, focusing on its innovative design, implementation, and scalability. By examining the program's pedagogical framework and initial outcomes, it offers adaptable strategies and actionable insights for institutions seeking to modernize doctoral education. Grounded in contemporary career development frameworks, the OPTIONS program prioritizes self-reflection, iterative career exploration and experiential learning, equipping students with the skills and confidence to navigate diverse professional paths. Although still in its early stages of assessment, the program's preliminary outcomes provide valuable insights for future development, ensuring its continued responsiveness to student needs and the demands of an evolving job market. This paper highlights how the OPTIONS program addresses these challenges by combining theoretical frameworks, a dynamic learning environment, and labor market insights to prepare students for a variety of career opportunities.

Learning environment

The OPTIONS program's learning environment is structured in three distinct phases, each designed to meet students' evolving career development needs during their doctoral training. Each phase builds on the previous one, guiding students from broad career awareness to focused career exploration and hands-on experience. As illustrated in Figure 1, the OPTIONS program's three-phase structure highlights key activities and intended outcomes across each phase.

Phase 1: career awareness (Years 1–2)

During the first 2 years, students are introduced to a broad range of career paths across academia, industry, government, and the nonprofit sector. This phase focuses on increasing students' awareness of various professional options and helping them identify paths that align with their interests and goals.

Career panels, co-hosted with student groups, provide insights into both research-intensive and non-research-intensive roles, allowing doctoral students to connect with PhD-trained professionals across various fields. Topics are chosen based on national career trends, student survey feedback, and alumni career outcomes, ensuring content remains relevance and responsiveness to student needs. Approximately six to seven panels are held annually. Each panel includes a structured Q&A led by a student moderator, covering essential skills required for each career path, strategies for skill development, and resources for further exploration. Students are encouraged to participate in panels that pique their curiosity and align with their interests. While only four career awareness activities (approximately 4–6 h of programming) are required for Phase 1, students are encouraged to engage in additional targeted activities to further explore their interests.

Reflections in the university's Canvas LMS help students articulate their understanding of the career paths discussed, evaluate alignment with their interests and skills, and outline actionable steps for skill development. These exercises lay the groundwork for deeper exploration and skill-building in subsequent phases, fostering a habit of self-directed learning. This phase not only introduces students to career possibilities but also aims to foster an initial sense of confidence in exploring and aligning their academic expertise with various career options.

Phase 2: exploration and networking (Year 3)

In the third year, as students shift from structured coursework to primarily focus on dissertation research, the OPTIONS program encourages deeper career exploration through structured programming and an informational interview assignment. Programming includes 1.5-h virtual workshops, half-day in-person symposiums, and other career education events organized around four primary career tracks: Biotech & Pharma, Science Policy & Communications, Business Side of Science, and Academic Research. Students are required to complete at least six workshops or a minimum of 8 h of career education programming. By offering virtual workshops, recorded content, and flexible participation requirements, OPTIONS ensures accessibility for students managing research, personal commitments, or geographic limitations.

Each track features PhD-level guest speakers who share insights into essential skills, daily responsibilities, and the nuances of their professions. For instance, programming within the Biotech & Pharma track explores drug discovery, clinical operations, regulatory affairs, medical affairs, and commercial operations, all led by alumni and industry professionals. The Science Policy & Communications track includes sessions on policymaking, advocacy, diplomacy, medical communications, journalism, and outreach. Meanwhile, the Business Side of Science track explores roles at the intersection of business and science, including careers

Year(s)	Phase	Focus Area	Required Activity	Intended Outcomes
1-2	1	Career Awareness	4-6 hours of programming	-Increase awareness of career opportunities for biomedical PhDs -Apply gained knowledge to refine career interests
3	2	Exploration & Networking	8-10 hours of programming Informational interview assignment	-Explore career path(s) of interest and understand the skills needed for success -Identify experiential learning and other relevant activities -Expand professional network through informational interviews
4+	3	Experiences & Skills	None; each student designs their own experience	- Apply gained knowledge to further explore chosen career path(s) - Participate in experiential learning activities and other opportunities - Enhance skills and competencies for future career success

FIGURE 1
The three-phase structure of the OPTIONS program, including key activities and intended outcomes.

in technology transfer, patenting, business development, consulting, venture capital, and entrepreneurship. The Academic Research track provides perspectives on various faculty positions, including discussions on the academic job market, grant writing strategies, and balancing lab management with mentoring responsibilities in a research setting.

To promote equity and flexibility, OPTIONS integrates external opportunities with program-led activities. Students can choose from pre-approved options, such as participating in the Johns Hopkins Teaching Academy or shadowing medical professionals to explore clinical careers. They may also propose alternative activities that align with their interests and the program's overall objective. This flexible approach encourages students to pursue authentic, personally meaningful opportunities that align with their unique career aspirations.

Finally, each student must complete at least one informational interview, encouraging them to connect directly with professionals in their areas of interest. The LMS OPTIONS course offers resources to assist students in identifying potential interviewees, including step-by-step guidance on leveraging LinkedIn for networking. Students document these experiences and reflect on what they learned, how their skills and values align with specific roles or fields, and what actionable steps they can implement. These reflections deepen students' understanding and prepare them for experiential learning in Phase 3.

Phase 3: experiences and skills (Year 4+)

The final phase emphasizes experiential learning, allowing students to apply foundational knowledge and skills to real-world contexts. Many students are first introduced to these opportunities during Phases 1 and 2, and their initial interest in these activities is often tracked through their reflections. The foundation built in earlier phases enables students to make informed decisions about which experiences to pursue in Phase 3. Common activities include paid internships at for-profit and non-profit organizations, mentoring programs that pair students with industry professionals, advanced coursework in areas such as data science or science policy, and involvement in student-led, industry-focused groups (e.g., consulting, science policy and diplomacy, biotechnology). These experiences are designed to align with workforce demands by helping students develop specialized competencies, refine career trajectories, and expand professional networks, offering practical applications for their academic expertise.

Phase 3 is intentionally flexible, encouraging students to select opportunities that resonate with their unique career aspirations. To support their autonomy, the OPTIONS program provides access to design thinking and personalized goal-setting resources, which empower students to craft customized career readiness plans. In addition, students are strongly encouraged to meet with the OPTIONS

Program Director to refine their career plans and navigate any uncertainties.

To further enhance the impact of this phase, OPTIONS is expanding the Phase 3 framework within the LMS to include a dedicated space for students to document reflections on their learning outcomes, skill acquisition, and career progress. This updated platform will incorporate tools for tracking milestones, consolidating career planning efforts, and aligning activities with long-term aspirations. Structured reflection prompts will guide students in evaluating the relevance and impact of each experience, encouraging iterative career planning and continuous professional growth.

Through this experiential and reflective approach, Phase 3 aims to equip students with the skills, confidence, and adaptability needed to transition successfully into a competitive and evolving workforce. The emphasis on real-world application ensures that students are well-prepared to navigate diverse career landscapes and make meaningful contributions across academia, industry, government, and beyond.

Educational principles and framework

Co-curricular learning

The development and piloting of the OPTIONS program integrated best practices from JHU's educational frameworks, particularly those emphasizing co-curricular learning. Collaborating with the assessment and evaluation offices ensured the program met institutional standards while providing critical feedback necessary to refine our approach to program assessment and improvement. By aligning with JHU's frameworks, the OPTIONS program has contributed to a broader understanding of student development through structured feedback mechanisms and iterative evaluation processes.

Recognizing the value of learning beyond the traditional classroom setting, JHU is developing the JHU Comprehensive Learner Record (CLR), an innovative initiative that captures and highlights students' co-curricular achievements alongside their academic accomplishments. The CLR serves as a customizable, comprehensive portfolio that students can utilize to showcase their skills, knowledge, and experiences to prospective employers, faculty mentors, and professional networks. By integrating co-curricular activities with formal education, the CLR highlights a holistic view of student learning and development based on stated learning outcomes that align with students' program of study and career goals. This initiative not only documents achievements but also ensures co-curricular activities meet established standards and are assessed, contributing meaningfully to the students' educational and professional profiles.

The Council on Learning Assessment at JHU has played a pivotal role in establishing guidelines for evidencing and evaluating co-curricular learning. According to the Council's Co-Curricular Learning and Assessment document ([University Council on Learning Assessment, 2022](#)), effective co-curricular learning emphasized clear learning outcomes, authentic assessment methods, and alignment with institutional priorities. These standards ensure that co-curricular experiences are integral components of students' development, systematically integrated into the educational experience, and accurately reflected in assessment.

To facilitate this integration, an ad-hoc committee was established to identify qualifying co-curricular activities, their associated competencies, and how they could be assessed. Research supports the value of capturing learning from diverse settings, enhancing students' lifelong learning portfolios, and helping them present their knowledge, skills, and abilities to stakeholders ([Abrams et al., 2023](#); [Archer, 2017](#); [Elias and Drea, 2013](#); [Kuh, 2008, 2013](#); [Kolb, 1984](#); [Kolb et al., 2001](#)). The Co-Curricular Learning and Assessment document outlines strategies for aligning activities with specific learning outcomes and evaluating them through high-impact practices ([Kuh, 2008, 2013](#)), which support student engagement, learning, and success.

The OPTIONS program applies these principles by focusing on key outcomes such as self-efficacy, awareness of skills, transferability of skills, self-assessment, goal setting, and self-reflection. These outcomes foster a deeper understanding of personal and professional growth, grounded in established educational theories and principles. By integrating authentic assessments and high-impact practices, the program demonstrates the measurable value of co-curricular activities in student development.

By adhering to these guidelines, the OPTIONS program not only supports the integration of co-curricular activities but also ensures that these experiences are effectively measured, assessed, and valued. This approach enhances the overall educational experience, providing students with a comprehensive view of their achievements and preparing them for success in their future careers. The integration of co-curricular learning principles reinforces the OPTIONS program's focus on career readiness, aligning institutional priorities with student-centered growth.

Experiential learning theory

The Experiential Learning Theory (ELT) developed by [Kolb \(1984\)](#) best represents the theoretical framework that underpins the development of the OPTIONS program. The ELT framework builds upon [Dewey's \(1938\)](#) learning theory, which emphasizes that learning happens through hands-on experiences, active engagement, social context, a democratic process, and student reflection on their own experience. While Dewey's theory provides the philosophical foundation, the ELT provides structure for applying these principles ([Kolb and Kolb, 2017](#)).

[Kolb's \(1984\)](#) ELT introduces a cyclical model of learning that comprises two key stages: Grasping Experience and Transforming Experience. In the Grasping Experience stage, learners engage in Concrete Experience, where they participate in direct, hands-on activities, and Abstract Conceptualization, where they formulate theoretical understandings based on these experiences. For example, within the OPTIONS program, a biomedical PhD student might participate in a consulting workshop where they work with classmates and an alumnus consultant to analyze a life sciences case study, such as developing a market entry strategy for a biotech product. This Concrete Experience allows the student to apply both scientific knowledge and business skills. In the Abstract Conceptualization phase, students reflect on the experience, affording them the opportunity to refine their career interests.

The cyclical nature of Kolb's model supports continuous engagement, as learners cycle between experience, reflection, conceptualization, and experimentation. This iterative processing

supports metacognitive skills development, adaptability, and lifelong learning (Ertmer and Newby, 1996; Pintrich, 2002). By emphasizing experiential learning, the OPTIONS program equips students with skills to transfer and apply knowledge effectively across contexts, fostering both personal and professional growth.

Social cognitive theory

Social Cognitive Theory (SCT) emphasizes the role of self-regulation in guiding learning, goal-setting, and self-efficacy (Bandura, 1986; Schunk, 1990). The three processes central to self-regulation are self-observation, self-judgment, and self-reaction (Bandura, 1986). Self-observation involves monitoring one's behavior and performance, laying the foundation for reflection. Self-judgment entails evaluating performance against personal standards or external benchmarks. Self-Reaction includes emotional responses and motivational adjustments based on these evaluations.

Self-efficacy, or the belief in one's ability to achieve these goals, is influenced by prior experiences, attitudes, and the social context (Bandura, 1986; Schunk, 1990). Through self-assessment and reflection, learners build goal setting skills by focusing on specific, proximal goals that are more likely to be attained. Additionally, proximal goals play a critical role in sustaining motivation and enhancing self-efficacy. The higher the self-efficacy the more likely the learner will be successful in reaching the stated goals.

In the OPTIONS program, these principles are operationalized through structured activities like goal setting, self-reflection, and feedback. For instance, students begin their career exploration by identifying opportunities that align with their degree, skills, and interests. Reflection exercises within the LMS prompt students to document career insights, explore alignment with personal interests and values, and identify next steps for continued exploration or skill development.

Collaborative elements, such as Q&A incorporated into all panels and workshops, access to diverse speakers, and regular interactions with the OPTIONS Program Director, further strengthen these processes. Additionally, optional life design and goal setting events hosted throughout the year contribute to creating a supportive culture where students feel empowered to explore their interests and refine their goals. By fostering an environment rich in resources and opportunities, the program equips students with valuable skills designed to navigate career paths, adapt to challenges, and continuously enhance their competencies. This holistic approach ensures students are prepared to make informed decisions and can thrive in their chosen careers.

Evolving career development models

Early career development theories, often referred to as The Big Five, focused on matching individuals' fixed personality traits and aptitudes with specific occupations, reflecting a deterministic view of career guidance (Leung, 2008). These frameworks prioritized efficiency in aligning individuals with predefined job roles, emphasizing stable, inherent traits over dynamic, evolving career trajectories. As the world of work and higher education landscapes shifted, these positivist frameworks became less relevant. By the late

20th century, career and education theories shifted toward identity development emphasizing experience, agency, and personal narratives rather than fixed traits (Côté, 2006). This shift reflects the influence of changing economic conditions, evolving workforce demands, and heightened expectations for higher education to deliver career preparation and measurable outcomes (Dey and Cruzvergara, 2014). These modern frameworks better align with learner and employer expectations, recognizing that academic credentials alone do not directly translate to specific occupations. Graduates must effectively convey their educational qualifications, transferable skills, and attributes to align with employer expectations in today's competitive and multidisciplinary job markets (Smetherham, 2006). Additionally, they must articulate their educational experiences and competencies to navigate this increasingly dynamic landscape.

Modern career development programs have shifted toward activities that prioritize self-reflection, exploration of diverse career pathways, and informed decision-making. The OPTIONS program aligns with this constructivist, post-modern approach (Savickas, 2002; Brown et al., 2020), operating on two key assumptions: (1) career interests are socially constructed and can change over time through the influence of professional schemas and social contexts, and (2) career decision-making is an iterative process shaped by intersectional values, experiences, and changing circumstances (Savickas, 2020).

Programs like NIH's Broadening Experiences in Scientific Training (BEST) underscore the importance of integrating experiential learning with reflection to support career development for PhD trainees (Van Wart et al., 2020; NIH Common Fund, 2019). These approaches highlight how institutions can guide students toward relevant experiential learning opportunities while encouraging them to reflect on their goals and adapt to changing career landscapes. The OPTIONS program aligns closely with these principles. By combining structured experiential learning opportunities, such as university-led or employer-hosted internships and mentoring programs, with reflection and goal setting activities, OPTIONS empowers biomedical trainees to construct and refine their career narratives. This iterative process enables students to develop the skills and confidence needed to articulate their professional value to diverse audiences, effectively bridging the gap between academic training and the dynamic demands of the workforce.

Integration of life design and labor market

Life design principles, rooted in design thinking (Rowe, 1987), encourage individuals to approach career and personal development with curiosity, creativity, and adaptability. Core concepts include reframing challenges, prototyping solutions, and iterative reflection. These principles help students navigate uncertainty in the career landscape by fostering a mindset of exploration and resilience.

The OPTIONS program integrates principles of life design to address the complexities of an evolving job market. With private-sector employment for Ph.D. graduates now rivaling academia (Langin, 2019), and technological advancements reshaping industries, adaptability and continuous learning have become essential for career success. Reports predict that most future jobs will require skills that have yet to emerge (Dell Technologies & Institute for the Future, 2017), and many existing workforce skills may become obsolete within a few years due to rapid changes such as AI

adoption (edX & Workplace Intelligence, 2023). The OPTIONS program equips students with crucial skills needed to navigate this uncertainty by fostering the mindsets needed for lifelong career development.

Life design, a framework grounded in Savickas' (2002) Career Construction Theory and popularized by Burnett and Evans (2016), encourages exploration, experimentation, collaboration, and reframing challenges as opportunities. OPTIONS operationalizes these principles across its three phases, embedding career planning into the doctoral experience as an iterative and evolving process rather than a singular decision point.

A cornerstone of this approach is the continuous access students have to their past reflections throughout their doctoral program. Housed in the LMS, these reflections enable students to track their progress, revisit career insights, and refine goals based on evolving aspirations and experiences. This access supports long-term self-assessment, helping students connect their academic journey to professional growth.

To complement this, the program includes structured activities that foster collaboration, career navigation skills, and reflective practices. Annual design thinking workshops provide opportunities for students to reframe challenges as opportunities and develop innovative solutions, while curated career development resources support exploration across four primary tracks: Biotech & Pharma, Science Policy & Communications, Business Side of Science, and Academic Research.

By embedding life design principles and integrating self-reflection with goal-setting and experiential learning, OPTIONS equips students to articulate their professional value and adapt to shifting workforce demands. The program empowers students to innovate, thrive, and make meaningful contributions in diverse career landscapes.

Methods

Multiple methods were used to evaluate the OPTIONS program, incorporating both quantitative and qualitative data collected at key timepoints. Surveys, institutional reports, and alumni career tracking were used to assess program outcomes, student demographics, and career trajectories. This study was reviewed by the Johns Hopkins University Institutional Review Board (IRB) and deemed exempt under program evaluation guidelines.

Surveys were administered at pre-determined intervals to measure changes in career awareness, self-efficacy, and goal setting confidence. The first survey was deployed at the start of Phase 1 (August–September of Year 1) to establish baseline career awareness and perceived skills. Corresponding surveys with the same baseline questions were administered at the beginning of Phase 2 and Phase 3 (August–September of Year 3 and Year 4, respectively) to evaluate changes over time. Survey participation was voluntary, which led to varying response rates.

Survey instruments include Likert-scale questions and open-ended prompts designed to assess participants' career development and skill acquisition. Initially developed using Microsoft Forms and distributed via email, the surveys were transitioned to Qualtrics in August 2022 and embedded into the university's LMS to enhance accessibility and participation.

The surveys are structured to include consistent pre- and post-survey questions that assess core outcomes, such as confidence in transferable skills, knowledge of career pathways, and career planning strategies. Reflection-specific questions are unique to the post-survey and are designed to capture qualitative insights into students' evolving career goals, experiences, and skill development. This design allows for meaningful pre- and post-program comparisons while providing deeper context through reflection.

Additionally, post-activity reflection prompts were introduced, in the LMS course, in Phases 1 and 2. These prompts focus on helping students articulate their takeaways from career exploration activities, offering additional qualitative insights into their learning process. Sample survey instruments and reflection prompts are provided in Appendices A–C for reference, illustrating both the consistency of core survey questions and the tailored nature of the post-survey reflections.

Demographic information, including gender, citizenship status, and underrepresented minority (URM) representation, was obtained from the Johns Hopkins University (JHU) Student Information System (SIS). Please note, demographic data were available only for overall program participation, but not for the subset of survey respondents whose responses are the focus of the Results section. Alumni career outcomes were tracked through a combination of self-reported updates and publicly available LinkedIn profiles, providing a comprehensive understanding of program outcomes. To categorize these outcomes, a framework informed by the Unified Career Outcomes Taxonomy (UCOT) was utilized (Stayart et al., 2020). This taxonomy employs a standardized, three-tiered classification system encompassing workforce sector (e.g., academia, government, for-profit, nonprofit), career type (e.g., primary research, science-related, teaching), and job function (e.g., postdoctoral fellow, staff scientist, consultant). Additionally, program learning outcomes were mapped to the career tracks emphasized in the OPTIONS program to ensure alignment with program goals and reflect broader workforce trends. ChatGPT (OpenAI, 2024) was used during the revision process to harmonize the writing styles of multiple authors and enhance manuscript coherence. The final manuscript was reviewed and edited by the authors to ensure accuracy and alignment with scholarly standards.

Results to date

The OPTIONS program has demonstrated substantial growth since its inception in 2017. Initially piloted with 18 students in a single PhD program, the program expanded to include 311 current participants across six PhD programs by 2023. Combined with 56 alumni who have completed the program, total cumulative enrollment has reached 367 students. Year-over-year growth has been significant; for example, enrollment increased by 133% from 18 participants in 2017 to 42 in 2018, and annual cohort sizes have grown approximately 270% from 2017 (18 participants) to 2023 (67 participants). This expansion has been facilitated by strong institutional support and strategic integration into biomedical and life science T32-funded doctoral training programs at the Johns Hopkins School of Medicine (JHSOM) and Bloomberg School of Public Health (JHSPH) (Table 1).

Demographic data reflect a diverse group of current and past participants in the OPTIONS program. Gender distribution among participants is approximately 37% male and 63% female. Additionally, 25% of students are identified as underrepresented minorities (URM),

TABLE 1 PhD training program partnership and student participant (2017–2023).

PhD training program	2017	2018	2019	2020	2021	2022	2023	Total # of students/ PhD program
JHSOM Cellular and Molecular Medicine (CMM)	18	19	16	18	17	22	19	129
JHSOM Biochemistry, Cellular and Molecular Biology (BCMB)		23	18	21	18	16	13	109
JHSOM Pharmacology and Molecular Science (Pharm)			7	7	11	9	9	43
JHSPH Microbiology and Molecular Immunology (MMI)			6	12	6	9	11	44
JHSPH Biochemistry and Molecular Biology (BMB)				12	7	4	3	26
JHSOM Human Genetics and Genomics (HGG)						4	12	16
Total # of students/ year	18	42	47	70	59	64	67	Overall total 367

Data shows the enrollment trends across various PhD training programs from 2017 to 2023. The number of students in each program and the total number of students per year are summarized. Data for current students was sourced from the Student Information System (SIS) reports, a comprehensive university database that tracks student enrollment and demographics.

TABLE 2 Demographic distribution.

Category	Total	Percentage
Gender		
Male	136	37
Female	231	63
Underrepresented Minorities (URM)		
Yes	93	25
No	267	73
Unknown	8	2
U.S. Citizenship or Permanent Residency		
Yes	309	84
No	56	15
Unknown	2	1
Degree status		
Doctoral student	311	84
Alumni, PhD degree holder	49	13
Alumni, Master's degree holder	7	2

This table presents demographic data for all participants in the OPTIONS program, including both current students and graduates. It details representation by gender, underrepresented minorities (URM), citizenship, and degree status. Data was sourced from the Student Information System (SIS), a comprehensive university database tracking student enrollment and demographics.

and 15% are international scholars who are not U.S. citizens or permanent residents. Among the total population of participants, 85% are pursuing doctoral degrees, while 49 alumni have completed their PhDs and 7 hold a Master's degree (Table 2).

Preliminary data on PhD alumni outcomes demonstrate diverse career trajectories (Table 3). Of the reported outcomes, 27% hold scientist positions in the for-profit sector (industry), 22% are in postdoctoral fellowships in academia, 8% in nonprofit or government postdoctoral roles, and 4% in industry postdoctoral positions. Additionally, 14% of graduates transitioned into business-related science roles (e.g., consulting, venture capital), 4% hold full-time staff scientist positions in academia, and 6% are pursuing additional education. Approximately 14% of alumni have not yet reported their employment status. These data reflect the OPTIONS program's success in preparing PhD graduates for a wide range of professional opportunities.

To quantify the program's impact, a statistical analysis was conducted on self-assessment data from Cohorts 2018 and 2019, comparing pre-assessment scores collected at the beginning of Year 3 with post-assessment scores at the beginning of Year 4 (Table 4A). Using an unpaired t-test, statistically significant improvements were observed in multiple areas. For instance, in Cohort 2018, the average score for awareness of specific actions to develop career-related skills increased from 3.29 to 3.77 ($\Delta = 0.48, p = 0.03$). Similarly, in Cohort 2019, this score improved from 3.48 to 4.00 ($\Delta = 0.52, p = 0.04$). Additionally, the ability to articulate how skills developed during graduate training translate into careers of interest improved significantly

in Cohort 2019, increasing from 3.81 to 4.40 ($\Delta = 0.59, p = 0.01$). While other improvements, such as identifying what career-related skills that require development prior to graduating, did not reach statistical significance, the positive trends observed across both cohorts highlight the program's role in fostering career-related skills and self-efficacy.

While the program has demonstrated clear benefits, survey completion rates declined over time, particularly for follow-up assessments. In Cohort 2018, the Pre-Year 3 survey achieved an 83% completion rate, but this dropped to 71% for the Post-Year 3 survey and 57% for participants who completed both assessments. A similar

trend was observed in Cohort 2019, with completion rates decreasing from 57% for the Pre-Year 3 survey to 32% for the Post-Year 3 survey and 26% for participants completing both surveys (Table 4B).

Discussion

The OPTIONS program has emerged as a transformative model for integrating career development into biomedical PhD training, addressing a longstanding gap in preparing doctoral students for diverse career paths. Since its pilot launch, OPTIONS has expanded from one partner program to six, demonstrating its scalability and adaptability across academic environments at JHU.

Aligned with national initiatives like the NIH Broadening Experiences in Scientific Training (BEST) program, OPTIONS integrates experiential learning, self-reflection, and iterative career exploration to prepare PhD trainees for diverse career pathways (NIH Common Fund, 2019; Van Wart et al., 2020). By embedding structured reflections within the LMS and incorporating design thinking workshops, OPTIONS equips students with tools to approach career planning as a dynamic, evolving process rather than a static decision point (Mathur et al., 2018).

Preliminary self-assessment data reveal promising improvements in students' career awareness and confidence in transferable skills. Statistically significant gains in their ability to identify actionable career development steps and articulate the transferability of their skills signal important milestones in the iterative process of career exploration and development. However, declining survey completion rates present challenges in compiling comprehensive datasets. Completion rates were highest when surveys were tied to required

TABLE 3 Preliminary data on alumni outcomes.

Career outcome	Total	Percentage*
Scientist position in industry	13	27
Postdoctoral fellowship in academia	11	22
Postdoctoral fellowship in non-profit/government	4	8
Postdoctoral fellowship in industry	2	4
Business-related science role (e.g., consulting, venture capital)	7	14
Staff scientist position in academia	2	4
Pursuing additional education	3	6
Employment not reported	7	14

This table presents preliminary data on the career outcomes of the first 49 PhD alumni who participated in the OPTIONS program. Career outcome data were obtained through a combination of self-reported updates and publicly accessible LinkedIn profiles, offering an initial overview of post-graduation trajectories.

*Percentages do not total 100% due to rounding error.

TABLE 4 Self-assessment of skill development and career awareness.

(A)						
Statement	Cohort 2018			Cohort 2019		
	Pre-Year 3 Average (n = 35)	Post-Year 3 Average (n = 30)	Δ	Pre-Year 3 Average (n = 27)	Post-Year 3 Average (n = 15)	Δ
I know what career-related skill(s) I need to further develop before graduating.	3.57	3.90	+0.33	3.56	3.80	+0.24
I am aware of specific actions I can take to develop these skills.	3.29	3.77	+0.48*	3.48	4.00	+0.52*
I can articulate how skills developed during my graduate training translate into my career(s) of interest.	3.74	3.97	+0.22	3.81	4.40	+0.59*

(B)							
Cohort	Total # of students	Pre-Year 3		Post-Year 3		BOTH Pre- and Post-Year 3	
		# of Completed surveys	Completion rate (%)	# of Completed surveys	Completion rate (%)	# of Completed surveys	Completion rate (%)
2018	42	35	83	30	71	24	57
2019	47	27	57	15	32	12	26

(A) Presents the self-assessment scores from the 2018 and 2019 cohorts, measuring students' awareness and understanding of career-related skills and their development over time. Data were collected at the beginning of Phase 2 (pre-Year 3) and after its completion (post-Year 3), with changes (Δ) indicating the difference between these two time points ($*p \leq 0.05$). (B) Shows the pre- and post-survey completion rates for both years.

in-person events, such as the Fall 2024 Year 1 Survey, which achieved a 92% completion rate during the “OPTIONS Retreat” for incoming first-year students. This highlights the importance of integrating surveys into structured programming to enhance participation and data reliability. Moving forward, efforts will incorporate mixed methods approaches to analyze qualitative feedback, such as open-ended survey responses and self-reflection prompts, to further illustrate the program’s transformative impact. Additionally, systematic approaches for validating self-reported data and improving alumni outcomes tracking will ensure consistent and accurate assessments of career trajectories.

Beyond individual student outcomes, OPTIONS has shown institutional benefits. Prospective students frequently cite the program in personal statements and post-visit thank-you notes, highlighting its value as a recruitment tool. Additionally, NIH T32 reviewers have recognized OPTIONS as a core institutional strength, reflecting its alignment with JHU’s strategic priorities of enhancing PhD training and supporting student success across diverse career pathways.

Looking ahead, the program will incorporate new training modules focused on resiliency and communication skills. Resiliency has been shown to enhance adaptability and recovery in professional settings (Green and Murphy, 2019), while effective communication is increasingly recognized as critical for fostering collaboration and engagement in diverse environments (Ayoko et al., 2021; Adams and Zhang, 2022; Knobel and Reisberg, 2022). By integrating these competencies, OPTIONS aims to address the growing importance of adaptability and collaboration in a dynamic and interdisciplinary workforce.

While the OPTIONS program has demonstrated early success, ongoing evaluation remains essential to ensure its continued relevance and impact. A longitudinal evaluation is planned to provide deeper insights into sustained program outcomes. Programming will continue to evolve based on student feedback and workforce trends, and efforts to scale the program to additional PhD programs and collaborate with external professional development initiatives will broaden access to its resources.

The OPTIONS program exemplifies a transformative approach to embedding career development into doctoral training. By aligning with national best practices, fostering lifelong learning, and addressing labor market demands, OPTIONS equips students to navigate diverse professional trajectories and positions them for long-term success in an evolving professional landscape.

Data availability statement

The original contributions presented in the study are included in the article/[Supplementary material](#), further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by Johns Hopkins University Homewood Institutional Review Board. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants’ legal guardians/

next of kin in accordance with the national legislation and institutional requirements.

Author contributions

CN: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. CA: Conceptualization, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. BL: Conceptualization, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. MO: Data curation, Project administration, Visualization, Writing – review & editing. CE: Conceptualization, Formal analysis, Methodology, Writing – original draft.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/feduc.2025.1478553/full#supplementary-material>

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