Title: A Structured Professional Development Curriculum for Postdoctoral Fellows Leads to Recognized Knowledge Growth

Kaylee Steen, Jay Vornhagen*, Zara Y. Weinberg, Julie Boulanger-Bertolus, Arvind Rao, Margery Evans Gardner, Shoba Subramanian*[#]

**Equal Contributions*

[#]*Corresponding author – shobas@umich.edu*

The authors declare no competing interests.

KS: Kaylee Steen, Cell & Developmental Biology Department, 109 Zina Pitcher Place
Ann Arbor, Michigan 48109-2200
Current: Medical School Office of Research, North Campus Research Complex (NCRC), 2800 Plymouth Road Building 520, 3rd Floor, Ann Arbor, MI 48109-2800, USA; steenk@umich.edu

JV: Jay Vornhagen, Department of Pathology, University of Michigan Medical School, 7514 Medical Science Building I, 1150 West Medical Center Dr., Ann Arbor, MI 48109-5615, USA; jayvorn@umich.edu

ZYW: Zara Y. Weinberg, Department of Pharmacology, University of Michigan Medical School, 1150 West Medical Center, 1150 West Medical Center Dr., Ann Arbor, MI 48109, USA
Current: Department of Biochemistry and Biophysics, University of California, San Francisco. 1700 4th Street, San Francisco CA 94158. weinberz@gmail.com

JBB: Julie Boulanger-Bertolus; Center for Consciousness Science, Dept. of Anesthesiology, University of Michigan, 7433 Medical Science Building I, 1150 West Medical Center Dr., Ann Arbor, MI 48109-5615, USA; jboulang@umich.edu

AR: Arvind Rao, Departments of Computational Medicine and Bioinformatics, Radiation Oncology, MIDAS; 100 Washtenaw Ave, Ann Arbor 48109; USA ukarvind@umich.edu

MEG: Margery Evans Gardner, Office of Graduate and Postdoctoral Studies, University of Michigan Medical School, 1135 Catherine St. Ann Arbor, MI 48109; USA maggieev@umich.edu

SS: Shoba Subramanian, Office of Graduate and Postdoctoral Studies and Department of Cell and Developmental Biology, University of Michigan Medical School, 1135 Catherine St. Ann Arbor, MI 48109; USA shobas@umich.edu 734-615-6511

Abstract:

Postdoctoral training enables research independence and professional readiness. National reports have emphasized professional development as a critical component of this training period. In response, many institutions are establishing transferable skills training workshops for postdocs. Critical gaps, however, have been the lack of structured programs and an absence of methods to assess outcomes beyond satisfaction surveys. To address these shortcomings, we took the relatively new approach of structured programming and developed a method for controlled assessment of outcomes. Our program You^3 (You, Your Team, Your Project), co-designed by postdoctoral fellows, focuses on a structured array of management and leadership skills agnostic of ultimate career path(s). It then measures outcomes in a controlled manner, by systematically comparing knowledge and growth of participants with non-participants as the control group. You^3 participants achieve greater growth in competencies overall compared to the control group, as shown by multiple criteria including self-reporting and associative analysis. Correspondingly, You^3 participants reported greater knowledge in 75% of the modules when compared to controls. These data indicate that structured learning, where postdocs commit to a curriculum via a cohort-structure, leads to positive outcomes and provides a framework for programs to assess outcomes in a rigorous manner.

Introduction:

Postdoctoral training is a unique period that is defined by the National Postdoctoral Association as “temporary time for scholarly work as well as acquisition of professional skills for career success”. To be successful in their next career step, postdoctoral fellows (referred to as ‘postdocs’ for the remainder of this paper) need to develop a wide variety of skills, including technical and non-technical skills. Although the importance of technical skills has been recognized for many years, growing evidence shows non-technical skills, also known as transferable skills, are also vital to succeeding as a professional during and beyond training (Committee on the Next Generation Initiative et al., 2018; Fuhrmann, 2016; McConnell et al., 2018; Mitic & Okahana, 2020; Sinche et al., 2017). A well-rounded portfolio is especially important in current times, where less than 25% of the PhD graduates move on to a tenure track (TT) position, while the rest pursue a distinct array of individual paths (Langin, 2019).

The unique nature of the postdoctoral training period presents several challenges for developing transferable skills. Postdocs are hired by individual faculty advisors and do not typically enter the academic system as part of a cohort. They start their appointment asynchronously, and the orientation, onboarding routines, and access to non-research resources are highly variable within and across academic campuses. Postdoctoral training is largely apprentice-based, leading to disparities in the scope and breadth of training, depending on their advisor’s experience and encouragement in combination with institutional support for expanded learning opportunities. The lack of structured professional skill development opportunities under serve the nearly 80% of PhD students that go on to do postdoctoral training (Kahn & Ginther, 2017). Many institutions face these limitations (Hitchcock et al., 2017), due to a combination of constraints on incentives, resources, personnel, and budget Even in the case where there are more professional development resources to build programs, both access to and utilization of these programs vary heavily depending on the individual trainee’s circumstances.

Two key factors that have been identified as critical limitations in training postdocs are a lack of structured programs for standardized training and a lack of methods to assess outcomes scientifically. Research institutions are investing resources at the university, college, and departmental levels to provide seminars and workshops often based on the postdoc core competency guidelines set by the National Postdoctoral Association (nationalpostdoc.org). Although well intentioned, these programs often follow an *ad hoc* pattern of topics and

schedules with little structure or accountability. A lack of a sequential structure leads to discontinuous learning, which can be ineffective (Yost et al., 2014). A lack of a cohort or peer structure for postdocs compounds this issue even more, leading to loss of peer-community groups and peer learning with a higher impact on historically excluded groups (Eisen & Eaton, 2017; Ross et al., 2016). Most professional development programs also get segregated by academic or non-academic career paths. This segregation makes it difficult for those who are undecided to choose the right program for them. These career-goal based professional development programs also lose the benefit of exchange and discourse between individuals of different mindsets and backgrounds. The lack of structure is beginning to be addressed by systems like the NIH BEST program (Meyers et al., 2016) which recognizes the vital role of a robust infrastructure for professional development in scientific and science-related careers. Importantly, however, even when institutes put in place structured professional development programs, outcomes are primarily assessed using basic methods such as satisfaction surveys. A lack of rigorous assessments is pervasive across all types of skill building programs. As of now, we have no clear and controlled assessment methods that measure participants' knowledge and growth in the topic in comparison to control groups who did not participate in the programs.

To effectively address these key limitations, we developed and implemented an innovative leadership and management program titled You^3. Our structured program used a cohort-based and sequential curriculum to empower postdocs as co-creators and co-designers of this plan, and then measured knowledge and growth in a controlled method, compared to nonparticipants. Our results show that participants increased their knowledge and growth in several key transferable skills that were measured. We propose You^3 as a scalable framework that can seed and establish similar opportunities for postdocs in other institutions across the nation.

Materials and Methods:

Needs Assessment Data Collection:

1. **miLEAD data:** Using the 2016 University of Michigan (UM) ADVANCE training assessment survey, 100+ questions were sent by the miLEAD consulting team, a trainee-led organization, to current and former graduate students and postdocs from departments or programs within or affiliated the University of Michigan Medical School (UMMS). The survey

received 527 responses with the breakdown of demographics being 28.2% current graduate students, 20.5% former graduate students, 45.1% current postdocs and 6% former postdocs. Three major themes were identified from analyzing the responses: Academic Community, Career Preparation and Learning Opportunities. Four focus groups were conducted for one hour each and comprised 18 graduate students (9 female and 9 male) and 18 postdocs (10 female, 8 male, 10 U.S. citizens and 8 non-U.S. citizens). Each focus group consisted of 8-10 participants and guided questions that covered the three major themes with an observer taking detailed notes and audio-recordings (maintaining participant anonymity). At the end of the session, participants also completed an anonymous questionnaire. The data shown in this manuscript represent the above survey results. To identify desired skills for prospective applicants, 36 interviews were conducted from multiple employment sectors including Academia, Biotech-Pharma, Legal-IP, Tech Transfer, Consulting, Writing, Government, and Bioinformatics. miLEAD also analyzed 192 job postings to identify the list of required and preferred applicant skills, experience and attributes. Collectively, these data surfaced the top skills that led to a hiring offer and the perceived weaknesses PhD holders have in relation to these skills.

2. **UMMS Faculty survey:** Before program planning, we sent an anonymous needs assessment survey to University of Michigan Medical School faculty. The survey asked faculty to select all skills that applied to the question “Which transferable skills do you wish you had developed further prior to becoming a faculty member?”. Of the 266 respondents, 32.7% were Professors, 26.6% were Assistant Professors, 21.4% were Associate Professors, 5.2% were Clinical Instructional Faculty, 3% were Lecturers, 1.5% were Instructors, and 9.3% were Other. Faculty were able to select more than one skill in their response, and we counted the total number of times each topic was selected across each faculty category.

You^3 participant enrollment

Advertisement material of the You^3 program was widely distributed to UMMS postdoctoral fellows via emails and flyers. Prospective applicants were asked to reflect on their professional experience and goals in order to assess their intentions and commitment to the You^3 program. The questions were intentionally broad as to avoid self-selecting for postdoctoral fellows that were interested in a specific career trajectory over another. Supplemental Figure S1 displays complete application requirements. For reviewing the applications, we utilized a scale of 1-5 with 5 being excellent alignment with the applicant’s goals and the learning goals of You^3 and 1 being low alignment. Applicants with an average score of 4 or higher were automatically

accepted; applicants with a score between 3 and 4 were discussed by the committee, and a select few were requested to interview to better gauge their overall commitment and interest in the program. By this process, 33 of 35 applications were sent an acceptance letter into the program. 32 accepted the offer and committed to participation.

Self-assessment outcomes survey to control and participant groups

As a control group, all UMMS postdoctoral fellows received an online Qualtrics survey (IRB Exempt #HUM00172637) to anonymously assess their self-reported knowledge and growth in the eight topics covered by the You^3 program. Based on each participant's response, the survey items were binned according to the trainee's prior experience with any UM skills building workshop, no skills building workshop experience, or participation in the You^3 program. The following distribution of survey participants completed the questionnaire: You^3 participants (n=23); control group who participated in some kind of professional development programming at UM (n=18); and did not participate in relevant programming (n=35).

Statistical analysis for self-reported knowledge and growth metrics: For knowledge metric analysis, confidence score values were compared using Kruskal-Wallis test followed by Dunn's posthoc test, and Pearson correlation coefficients and P values were calculated for each category and metric. For growth metric analysis, text-based respondent data was converted into numerical data, wherein 4 categories (no growth, low growth, medium growth, high growth) were converted to numerical values (1-4, respectively). Odds ratios and associated 95% confidence intervals, as well as Pearson correlation coefficients and P values, were calculated for each category and metric. Kruskal-Wallis test followed by Dunn's posthoc test were performed using GraphPad Prism version 8, and Pearson correlation coefficient and P-value calculations were performed and visualized in R version 4.0.2 using the "Hmisc" package.

Results:

To establish a comprehensive program, we focused on four achievable goals: (1) addressing specific needs of postdocs immediately transitioning into the workforce, (2) using a holistic view of professional development over eight consecutive weeks, (3) developing a cohort model toward fostering community, and (4) enabling management and leadership skills agnostic of ultimate career choice. To meet these goals with evidence-based data, we factored in needs

assessments and workforce needs from the perspective of three key stakeholder groups: a) postdocs b) UM Medical School (UMMS) faculty c) employers hiring PhD holders.

In the first survey set, current and former postdoctoral fellows reported their expected career plans at the start of their PhD program compared to their current plans (Figure 1A). We observed that, broadly, professional goals shifted from an initial interest in academic positions to current interests in non-academic positions (Figure 1A). This corroborates a previous study from the University of California, San Francisco where career choices dramatically shifted in PhD trainees' third year (C. N. Fuhrmann et al., 2011). The shift in career plans was supported by the types of employment status reported at 1, 5, and 10 years post-PhD graduation of our PhD students (Figure 1B). Postdoctoral fellowships dominate the employment sector at 68% 1 year after graduation, but this drops to 46% and 9% at 5- and 10-years post-graduation, respectively. Conversely, all other positions increase at years 5 and 10 (Figure 1B). Thus, this breadth of employment outcomes clearly indicates that professional skill building and career exploration programming should be applicable to a variety of career choices.

To tailor the content that would be covered in the program that we were building, we augmented our career outcome results with data from (a) industry hiring managers and (b) current faculty surveys. First, deficiencies in professional skills were identified for PhD job applicants based on interviews with 36 industry professionals and analysis of 192 non-academic job postings (Figure 2A). From the top skills that emerged, communication, teamwork and management (project, time, personnel, and budgeting) were perceived as weaknesses of PhD degree holders seeking employment (Figure 2A). These data were complemented by an anonymous survey distributed to UMMS faculty. We asked them to identify among 15 different transferable skills at least one that they wish they had developed prior to becoming a faculty member. The responses pointed at six skills that were frequently selected as training desired before assuming their faculty roles. Starting with the most chosen, these skills included Grant/Scientific Writing, Team Building/Mentorship, Conflict Resolution, Statistics, Lab Business Management, and Lab Finances/Budgeting (Figure 2B). These data include responses from Assistant, Associate and Full Professors, and the results are consistent between all tracks. Similarly, previous surveys conducted with postdocs also indicated gaps in training related to team-building and management (data not shown). These collective data from trainees, employers, and faculty are consistent with published work on PhD-holding employees (Sinche et al., 2017).

In parallel, our group, which included the postdoc co-designers, had many robust discussions on lived experiences in seeking, building, and applying these transferable skills during training and beyond. As a result of this feedback, we focused on eight major topics that met the criteria of priority while being career agnostic. These topics were organized into three themes: Managing Yourself, Managing Your Project, and Managing Your Team. The breakdown of the program and the description of each topic is described in Figure 3. This process also resulted in branding the program as You^3: Leadership and Management Program for Postdocs: You, Your Team, Your Project (Figure 3).

We formally launched the inaugural You^3 program in September 2019 using targeted email marketing to postdoctoral fellows in UMMS and posted flyers across our research buildings. An open invitation intentionally queried diverse motivations for engaging in this program. as evident in the application prompts and selection protocol (Figure 4). The application requirements and the screening process gauged interest and commitment. In addition to a two-page resume, each applicant was asked to respond to one of four simple prompts on the topics of conflict resolution, interpersonal and team-work experiences, leadership, and project management (Figure 4). We then gathered data on their current career plans. As seen in Figure 5, out of 35 applicants, 19 were certain about one career path, whereas the remaining 21 chose more than one potential path. Furthermore, these 35 applicants represented 13 different departments at UMMS. After reviewing the applications, we conducted phone interviews for a small subset to confirm motivation and commitment. The committee finally invited 33 postdoctoral fellows to participate with 32 ultimately matriculating into the You^3 program.

The program included one 90-minute meeting per week for eight consecutive weeks. In addition, there was a welcome event the week prior to the first session and a closing reflection ceremony the week after the last session. Each 90-minute in-class session was a mix of didactic instruction by subject matter experts and group activities to enact or respond to scenarios and to reflect on and discuss pertinent topics. Pre-work, outside of class, included short readings and occasional self-assessment material. To further instill structure and weekly learning objectives of the You^3 program, the program content and calendar reminders were organized on Canvas, a Learning Management System used for courses at our institute. Finally, to encourage honest conversations and maintaining a safe space, there was a community agreement on maintaining confidentiality outside of the class. Figure 6 illustrates the overall framework for designing and implementing the You^3 program.

To encourage commitment to the program and to learn sequentially, full attendance allowed participants to receive a certificate of completion. We permitted pre-approved absences and excused attendance under reasonable circumstances. A small number of participants who could not physically be on campus chose the option of watching the program live stream on a video-conferencing platform. You^3 participants had significantly higher attendance percentages overall compared to other workshops held by our Office of Graduate and Postdoctoral Studies. Specifically, *ad hoc* professional development workshops during the same period had a postdoc attendance of 45% of those who submitted an RSVP, and themed professional development workshops was at 71%. Conversely, the You^3 program consistently had an attendance record of 95% (Figure 7).

To measure the impact of the You^3 program on participants, we decided not to rely on instructor evaluations due to their known biases (MacNell et al., 2015) and inadequacies (Hornstein, 2017). Moreover, instructors' perspectives would not inform us of the program's impact on participants. Instead, at the end of our program, we surveyed You^3 participating postdocs as well as non-participating UMMS postdocs as a control group to determine self-reported a) current knowledge and b) growth in the program time period on each of the eight program topics. Control respondents were further stratified between postdocs that have participated in any professional development programming at the University of Michigan and those that did not participate in relevant programming during the same months when the You^3 program was held. As seen in Figure 8, You^3 participants self-reported greater knowledge at the end of the program on the topics of Hiring and Interviewing, Implicit Bias, Building Your Team, and Budget Management compared to control groups that had received other professional development programming. Additionally, compared to the no-other-program controls, You^3 participants reported greater knowledge in all areas with the exception of time management and conflict resolution (Figure 8).

To determine if the relationship between comparatively independent, higher self-reported knowledge is associated with participation in the You^3 program, we also surveyed You^3 participants and controls on their self-reported growth in each of these skills over the timespan of our program. You^3 participants reported the highest growth across all skills (Figure 9A). Associative analysis revealed that You^3 participants had significantly higher odds of reported high growth in 3 of 8 metrics, medium growth in 7 of 8 metrics, and low growth in 1 of 8 metrics

(Figure 9B). Therefore, participation in the You^3 program was highly associated with growth in the topics covered by the You^3 program and suggests that the comparatively higher self-reported knowledge was due to participation in the You^3 program compared to the control groups.

To see if self-reported knowledge in one topic correlated with knowledge in any of the other seven topics or with years in postdoctoral training, we also performed Pearson's correlation analyses. We did not find consistent patterns from this analysis when measuring self-reported knowledge correlations for You^3 participants and previous programming controls. However, we did consistently find statistically significant correlations between all of the eight-knowledge metrics in the no previous programming control group (Fig S2). These correlations were generally driven by a paucity of self-reported knowledge across our topics, indicating a baseline insufficiency in postdoctoral training related to professional skills. A similar trend was observed when the same correlation analysis was conducted between the self-reported growth metrics, and growth was independent of years in postdoctoral training (Fig S2). These data indicate that lack of participation of transferable skills development programming prevents positive growth. Moreover, we posit that the You3 program is more effective at encouraging positive growth than *ad lib* engagement with transferable skills development programming

Finally, the end of program celebration had participants reflect using sticky notes, what they were 1) less afraid of; 2) more prepared for; 3) able to accomplish; and 4) inspired to achieve as a result of participating in the You^3 program. As seen in Figure 10, the highlighted responses show that the participants feel more confident and more empowered. Overall, the program was intentionally designed to build skills needed for a successful career launch that had been identified as areas of weaknesses by future employers. Our results demonstrate that participation in the You^3 program effectively improved self-reported knowledge and growth in the eight prioritized career-agnostic professional skills.

Discussion:

Our study describes a novel program that addresses critical gaps in professional development of postdoctoral fellows. Developed as a collaboration between the Office of Graduate and Postdoctoral Studies (OGPS) and postdoctoral fellows at the University of Michigan, we structured an array of management and leadership skills that are transferable across careers

and assessed program outcomes using rigorous scientific methods. We show that our structured approach resulted in a measurable increase in the participants' knowledge of and growth in multiple skills, compared to control non-participants. Interestingly, the increase was independent of time spent as a postdoc, indicating that experience alone was not enough to develop skills, and that active programming was necessary.

The unprecedented level of excitement, engagement, and commitment we catalyzed among the participants could be due to two key aspects of the program. The first is that the program was fully structured, which is uncommon. The opportunities currently available for skill building for trainees tend to be independent workshops that do not have the pedagogical structure and continuity necessary for comprehensive learning (Yost et al., 2014). This lack of structure is a problem especially for postdocs, as they have a short time frame to be productive and to transition from being a trainee to an independent professional (Committee on the Next Generation Initiative et al., 2018; Hitchcock et al., 2017; Sauermann & Roach, 2016). The structure we provided, based on data generated from surveys of the whole academic community, as well as future employer feedback and published literature, likely spurred engagement of the participants. The second key innovation was the extent of input from and involvement of four current postdocs, the target population, in designing the program. This is a notable difference between You^3 and most previous programs. An additional benefit of involving trainees during program development was that the postdocs who helped develop the program also grew as leaders and strategic thinkers. These benefits are consistent with previous reports where engaging college students early has been valuable in developing teaching methods and planning curricula (Bovill et al., 2011).

The novel method that we developed for assessing outcomes, modeled on the scientific method, is a key advance. Traditionally, educational and professional development programs rely on satisfaction surveys and/or instructor ratings, both of which are beset with issues such as bias and lack of depth (Senior et al., 2017; Uttl et al., 2017). Attempts to assess outcomes in more quantitative ways have been challenging, as these programs typically do not (and should not) use grades as a measurement of learning. The controlled assessments, comparing participants' knowledge and growth to non-participants' in the same time frame, was developed based on a method used in medical settings such as clinical trials. Because self-assessment and awareness form a significant part of the assessments, it is possible that the assessments were influenced by participants' awareness of what they did not know earlier.

We anticipate that the program will continue to evolve in several ways. Our immediate next goal is to optimize this program for virtual and hybrid formats. To understand why we observed a substantially higher level of participation in virtual workshops, a recent study conducted by our team unearthed several advantages that the video conferencing formats could offer professional development programming (Gardner et al., 2020). Another aspect of the program that would be informative is long-term tracking of the postdocs who have participated in this program. This longitudinal data, along with information on how other institutions are implementing similar programs, will strengthen our assessment. We also obtained direct critical feedback from the participants, which revealed accountability checkpoints and low stakes homework assignments as potential motivators. Data from other structured professional development programs created and implemented by our office indicate that a significant number of participants value built-in accountability measures (unpublished work). Based on all this feedback, in the next iteration of the You^3 program, we will include low stakes activities that can be done outside of the sessions for greater experiential learning. This additional tool will enable robust active learning inside the classroom. We also will include group-based assignments to build more community among postdocs who often suffer from isolation and loneliness (Arnold, 2014; Editorial, 2020) as well as provide asynchronous activities in topic areas of implicit bias and conflict resolution. Using this iterative approach, we aim to optimize the program to its most effective format.

The You^3 program is a novel, scalable, and rigorous framework that can be adapted by any institution to expand the foundation of postdoctoral training. Our structured program and scientific assessment of outcomes helps minimize the variabilities and inequities in experiences and outcomes prevalent in the current apprenticeship-based training models. You^3 can be adapted easily to institutional needs, including hybrid training models combining in-person and virtual formats. We anticipate that newly funded initiatives from the NIH, such as The Postdoc Academy (postdocacademy.org), will provide complementary and supplementary resources to make broad implementation feasible within the budgets of most institutions.

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Figure Legends

Figure 1: Employment interests and outcomes during and after training. Surveys were sent to >500 current and former graduate students and postdocs from 14 departments and programs within UMMS. (A) Postdoctoral fellows were surveyed on their initial interest in academic versus non-academic positions when starting their doctoral program compared to their current plans. (B) The employment status of graduate students was reported for 1, 5, and 10 years after completion of their PhD program.

Figure 2: Professional skills required for success in academic and non-academic careers. A) Interviews with 36 industry professionals and analysis of 192 non-academic job postings identified the professional skills employers seek in applicants. Those desired skills were separated into transferable and technical skills and marked as perceived weaknesses and strengths of PhD applicants based on industry interviews. B) A needs assessment survey was distributed to UMMS faculty (266 responded), who rated the value each skill contributed to their career success. The faculty surveyed represented tenure-track (assistant, associate, and full professor), non-tenure track (lecturer and instructors), clinical-instructional track, and "other" category. For clarity, shown are responses from full, associate, and assistant professors, but the results were consistent across all faculty categories.

Figure 3: Overview of You^3 program design, content, and implementation. Based on combined needs assessment and survey data, the You^3 program content addressed 3 major themes: Managing Yourself, Managing Your Project, and Managing Your Team. Topics were then organized by theme, and each one was presented over the 8-week program in the order indicated in the table.

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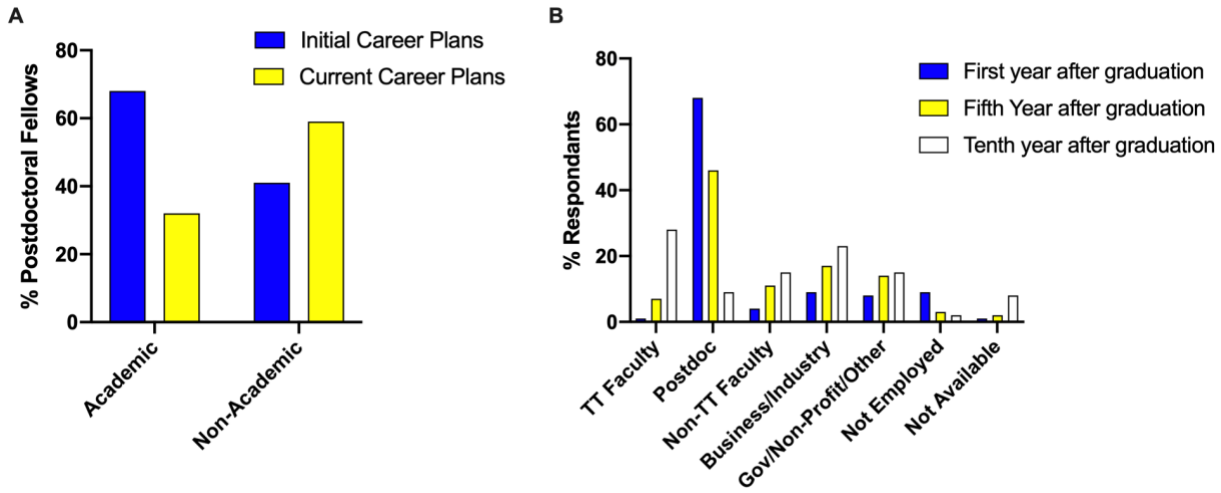
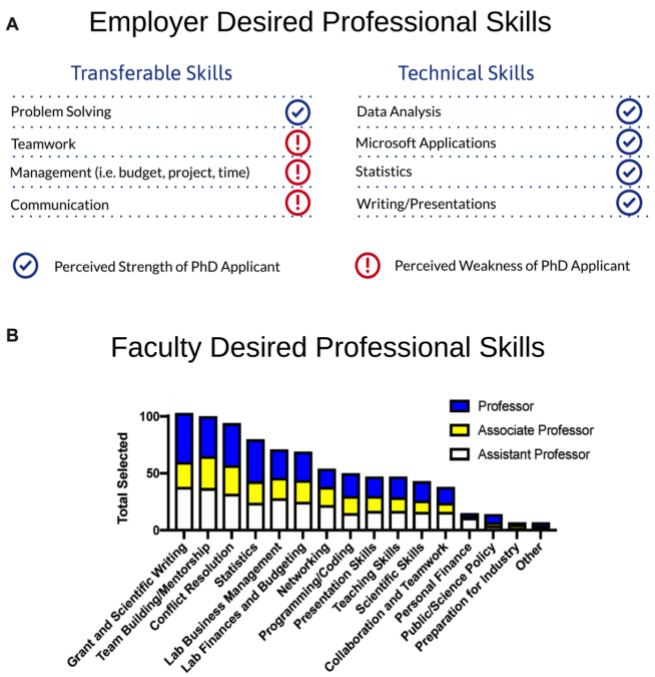


Figure 1: Employment interests and outcomes during and after training. Surveys were sent to >500 current and former graduate students and postdocs from 14 departments and programs within UMMS. (A) Postdoctoral fellows were surveyed on their initial interest in academic versus non-academic positions when starting their doctoral program compared to their current plans. (B) The employment status of graduate students was reported for 1, 5, and 10 years after completion of their PhD program.



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Postdoctoral Leadership & Management Program

YOU • YOUR TEAM • YOUR PROJECT

1.5 hour sessions for 8-weeks

Canvas learning management system

Managing Yourself	Managing Your Project	Managing Your Team
Self-awareness, strengths and accountability Identifying your strengths and weaknesses while leveraging constructive feedback to gain realistic self-knowledge **Implicit bias** Being aware of blind spots and working toward an inclusive environment **Time management** Identifying tasks that contribute to your professional growth, prioritizing them, and setting a reasonable timeline for your expectations	**Budget management** Developing a budget and managing funds **Hiring and Interviewing** Hiring and developing talent on your team	**Building your team** Assigning the right projects to the right people; communicating expectations, building trust **Conflict resolution** Resolving inter- and intra-team conflicts in a constructive manner **Leadership skills** Core skills to develop as a leader and learn to seek out future opportunities

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Program Application Prompts

1. Identifying information:
Name, Department,
Training Year, PI Details,
2-page Resume

2. Considered career paths:
Academic/Non-Academic
Faculty/Non-Faculty
Don't Know/Other

3. Primary motivation to attend this program (250 words):

4. Pick one topic below, tell us your experience & skills to improve:

conflict resolution issues
managing people effectively
leadership struggles
team dynamics problems

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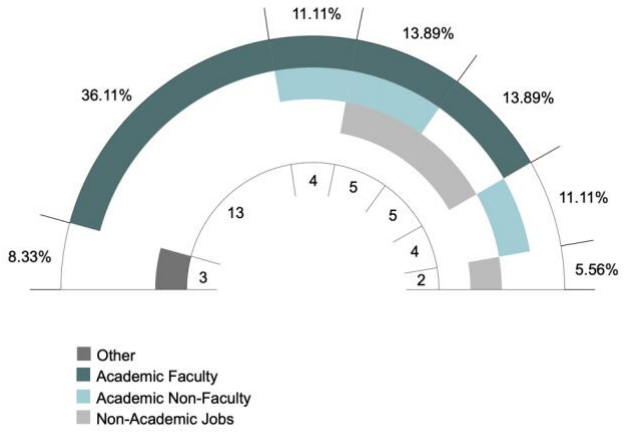

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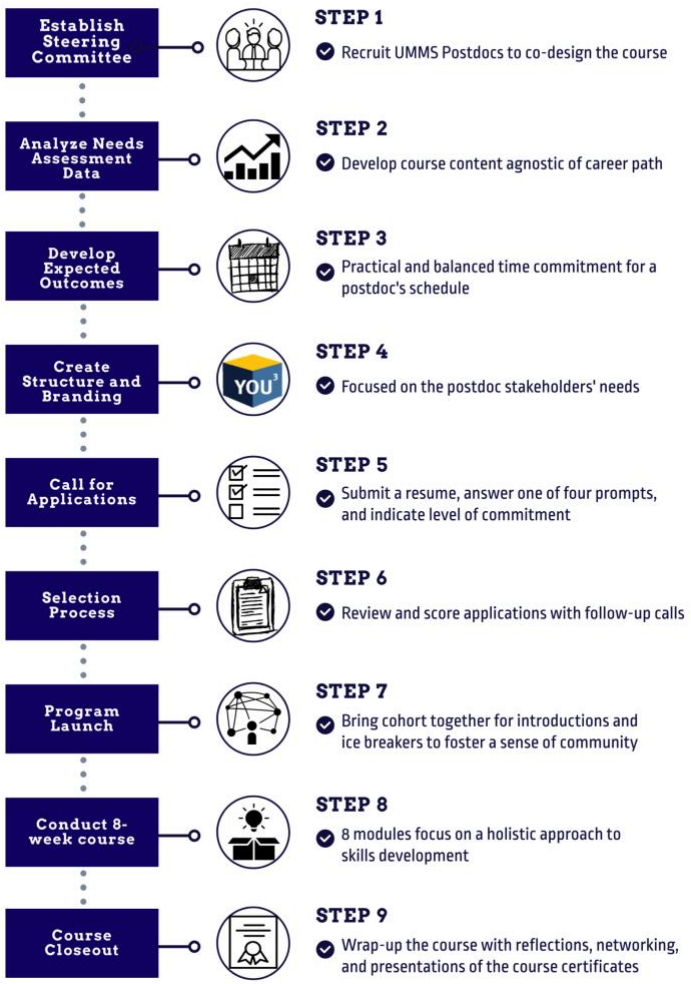

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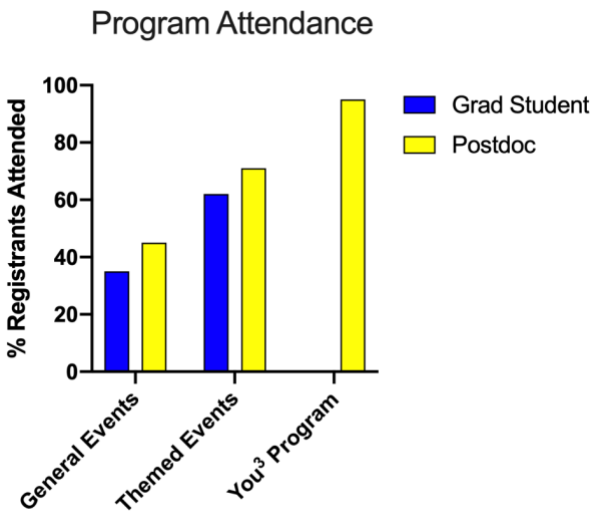

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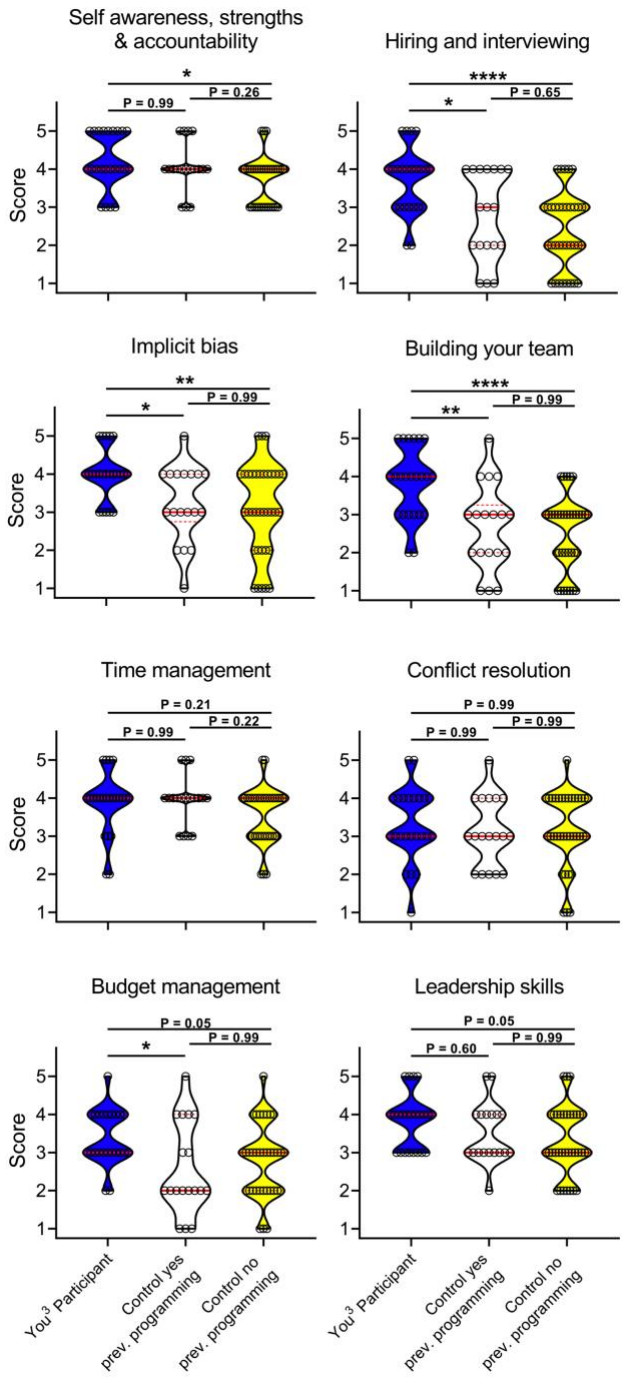

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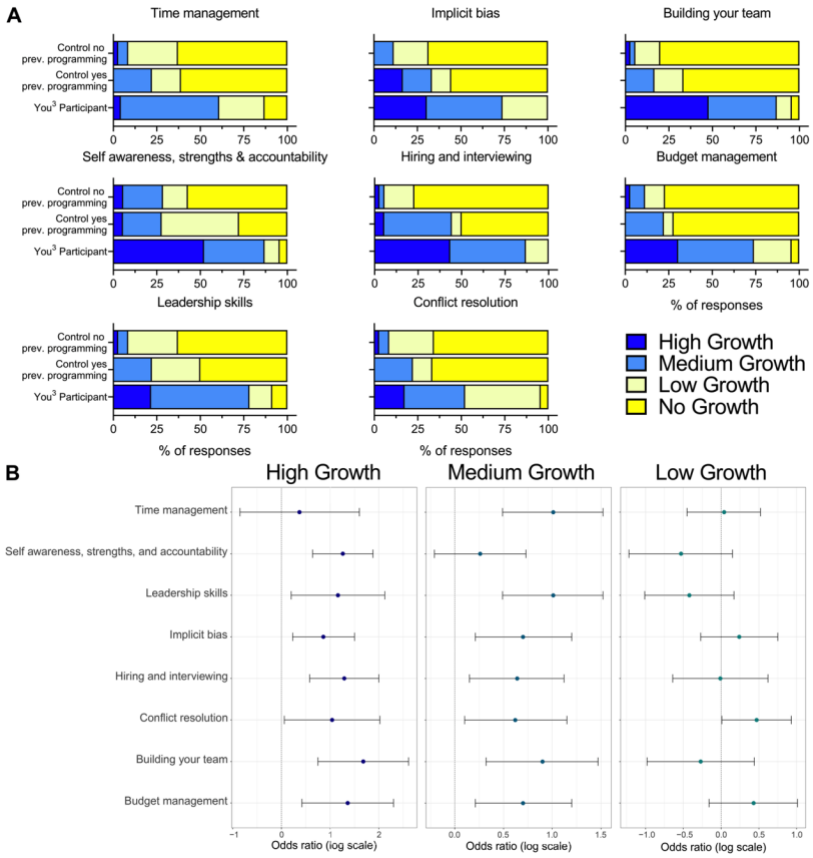

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You^3 Program Application Process

Identifying information:
- Name
- Primary Department
- Years in Doctoral Training
- Year PhD was Conferred
- Name and Email of Advisor

Considered Career Paths:
- Academic Faculty
- Academic Non-Faculty
- Non-Academic Jobs
- Don't Know
- Other

Long Response Prompts (250 word max):

1. Tell us your primary motivation to apply for the You^3 Program?

2. Describe a time... (select <u>one</u> of the following)

... when you had a *conflict or challenge* with a project that did not get solved effectively. What types of skills would you hope to learn from this course that could have helped you approach it differently?

... when you managed a person/people, what skills would be the most useful to be a *more effective leader* and why.

... where you struggled in a *managerial or leadership* role. What were the specific challenges? What skills from this course would be helpful and why?

... when you were part of a *team or project* that was not managed effectively. What were the issues and what steps did you or would you have taken to improve the experience?

Upload a Current Resume (2 page maximum)

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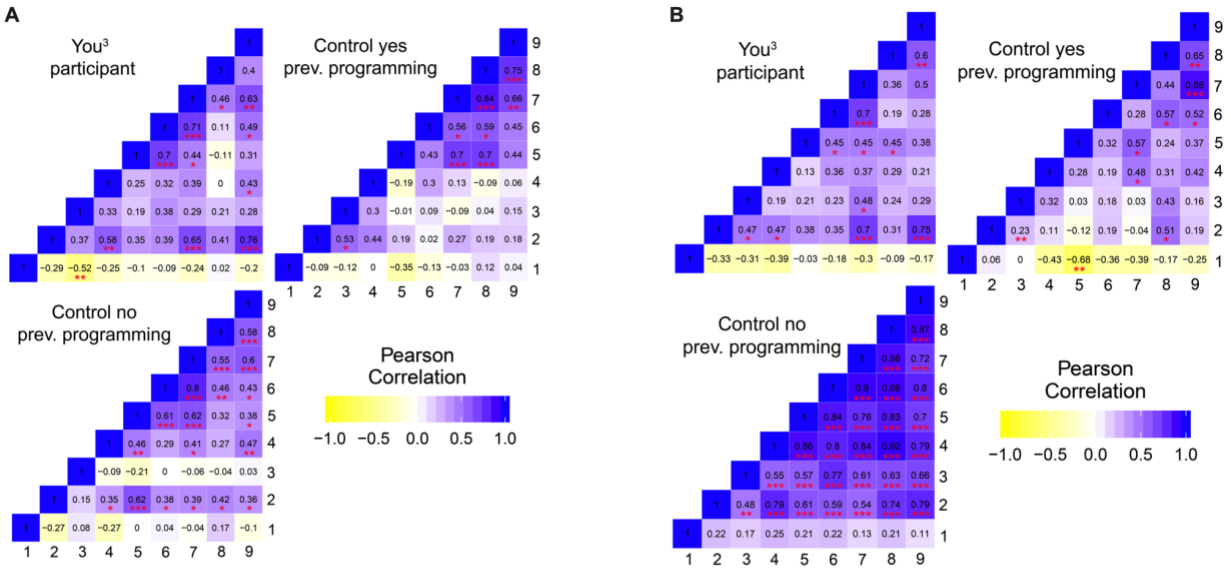

1. Years prior to 2019 in postdoctoral fellowship
2. Self awareness, strengths & accountability
3. Implicit bias
4. Time management
5. Budget management
6. Hiring and interviewing
7. Building your team
8. Conflict resolution
9. Leadership skills

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