



RESEARCH ARTICLE

REVISED Modeling individual development plans, mentoring support, and career preparedness relationships among Doctor of Philosophy (Ph.D.) trainees in the life sciences [version 2; peer review: 2 approved]

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Abstract

Background: As greater career development support for doctoral students and postdoctoral researchers has been emphasized, the individual development plan (IDP) has become a recommended mentoring tool. However, little is known about the effect of IDPs on mentoring and career development. This study proposed two conceptual models to examine the interrelationships among the use of IDPs, mentoring support, and career preparedness with a diverse sample of doctoral students and postdoctoral researchers in the life sciences.

Methods: The data leveraged for this study was collected over a three-month period, March 2016 to June 2016, as part of a cross-sectional, online survey. The survey was distributed through social media and direct email to participants enrolled in life/biological/medical or physical/applied doctoral programs at U.S. institutions. To test the proposed conceptual models, this study employed the design-based multilevel structural equation modeling.

Results: The analytic sample comprised 660 doctoral students and postdoctoral researchers in the life sciences from 91 institutions. The results suggested that 1) using the IDP could enhance mentoring support and career preparedness of doctoral students and postdoctoral researchers; 2) greater mentoring support and career preparedness would motivate mentees to continue utilizing the IDP with their principal investigator (PI) or advisor; and 3) females, postdoctoral researchers, and international scholars might need more support throughout the mentoring and career development process.

Open Peer Review

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1. **Adriana Bankston** , University of California Office of the President, Washington, USA

2. **Jessica Kathleen Polka** , ASAPbio, San Francisco, USA

Any reports and responses or comments on the article can be found at the end of the article.

Conclusions: This research offered empirical evidence for how an IDP, mentorship, and career preparedness interact. Findings revealed the IDP enhances mentoring support and career preparedness, as well as mentoring support and career preparedness predict IDP use. We conclude the IDP is an important mentorship tool that enhances trainees' overall career preparation.

Keywords

Individual Development Plan, Mentoring support, Career development, Doctoral education, Postdoctoral training



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REVISED Amendments from Version 1

In response to the reviewers' feedback, we have revised the manuscript by: 1) uploading a new Table 2, as well as expanding text to more fully describe the statistical differences of the IDP use, mentoring support, and career preparedness by trainees' backgrounds of this study; and 2) editing the manuscript in multiple places to improve readability. We have also responded to each reviewers' report.

Any further responses from the reviewers can be found at the end of the article

Introduction

At the core, doctoral education is intended as a career development catalyst. For example, doctoral students not only build their disciplinary foundation but also demonstrate capability of conceptualizing and conducting research through their dissertation. Experts agree that successful doctoral programs mentor dependent students¹⁻⁴ and develop them into independent scholars.^{2,5-7} However, today is a challenging time for many doctoral students and postdoctoral researchers, regardless of discipline. Pressures such as time to degree,^{8,9} student attrition,^{10,11} mental health-related issues,^{12,13} and the most recent challenges of the COVID-19 pandemic further emphasize the need for improved career development associated with the doctoral and postdoctoral environment.

Over the past decade a method used to elicit, support, and facilitate doctoral education dialogue emphasizing mentorship and career development is the individual development plan (IDP). This mentorship communication and career development tool is designed to prompt trainee development through self-reflection. Although IDP usage in non-academic sectors began in the last century when managers and organizations would align an individual's competencies within an IDP,¹⁴ the higher educational framework of the IDP was not introduced until 2002, when the Federation of American Societies for Experimental Biology¹⁵ developed the IDP for postdoctoral fellows in the life sciences. The most established example of the IDP is the web-based version titled "myIDP", which is a step-by-step platform that guides users through a process of (1) self-assessment, (2) career exploration, (3) goal-setting, and (4) implementation.¹⁶

Subsequent literature has suggested how individuals in graduate education and postdoctoral training can benefit from IDP adoption to identify and develop career readiness. For example, mentees benefit from IDP usage by developing skills (i.e., technical, professional or transferable), that enhance exploration and/or awareness of career paths.¹⁷⁻¹⁹ Researchers discovered that IDPs appear to be most effective when doctoral students and postdoctoral researchers have a positive mentoring relationship with their advisor, as well as engage in career development activities.^{20,21} Recent IDP research indicates that 51% of surveyed doctoral students reported that the IDP was helpful to their career development.²¹ The IDP is intended to be a vehicle doctoral students and postdocs can use to identify their career goals.²² However, IDP research highlights the need to close long-standing career development infrastructure gaps within institutions and external funding solicitations that impede an individual's career development.^{8,21-24} For example, integrating career development experiences early and often within the doctoral curriculum, institutions can encourage an expanded career readiness within their trainees by "hiring PhD scientists to direct career development programs".²³ Knowing that mentorship is closely associated with IDP effectiveness, faculty development programs are critical to improve both mentoring and the mentor's familiarity with the IDP process.^{8,18-24} However, Hobin and other researchers determined that only 20% of mentors were familiar with the IDP process,²⁰ and postdocs mentors often wait for their mentee to initiate career development discussions.²⁰ Similarly, additional IDP research discovered that mentees report having completed the IDP but not having discussions with their mentor.²¹

Falling under the larger recommendation to increase scholarship of mentoring,²⁵ there are calls^{19,21,22,24} for more studies to determine the effectiveness and uniqueness of IDPs, while increasing an awareness how various trainee background and characteristics impact IDP usage and mentoring. This study further examines the impacts of the IDP by investigating the interrelationships among the IDP, mentoring support, and career preparedness for doctoral students and postdoctoral researchers. Our hypotheses are formed from existing IDP literature,^{20,21,24} whereby two models are envisioned: 1) the IDP enhances an individual's mentoring support and career preparedness, and 2) mentoring support and career preparedness predict the use of IDPs, as shown in [Figure 1](#). Meanwhile, the mentee's backgrounds are also functioning over the process.

Methods

This research is part of a health and wellbeing study approved by the University of Kentucky (protocol 15-1080-P2H) and University of Texas Health San Antonio (protocol HSC20160025X) institutional review boards. Respondents read a cover page and consent was obtained through the online survey web link. Survey responses were anonymous, and participants were ensured of confidentiality.

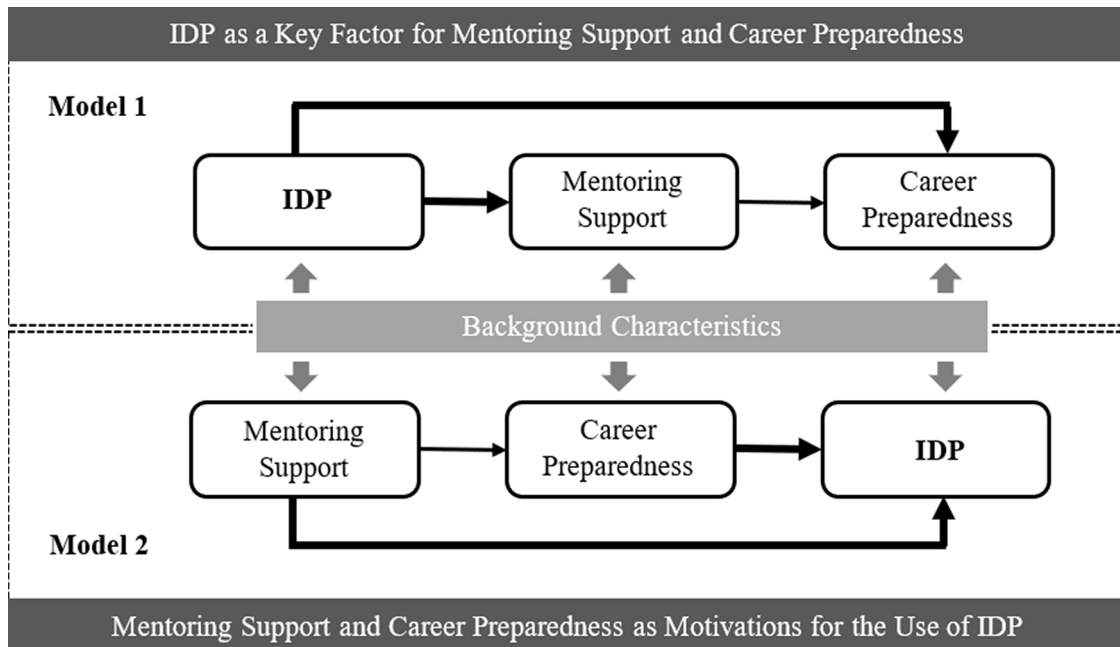


Figure 1. Conceptual models for the individual development plan (IDP), mentoring support, and career preparedness.

Data/sample

The data leveraged for this study was collected as part of a cross-sectional, online survey in the spring and early summer of 2016. Survey invitations were distributed via direct email and social media (primarily Twitter and LinkedIn) to the current doctoral students and postdoctoral researchers at different United States (U.S.) institutions. A total of 864 Ph.D. trainees from 116 institutions participated in the survey. After excluding those respondents who were not in Life/Biological/Medical Sciences, the final analytic sample consisted of 660 doctoral students and postdoctoral researchers from 91 institutions.

Measures

Mentoring support and career preparedness were collected using the five-point Likert scale from strongly disagree to strongly agree. Mentoring Support (MS) was constructed by four items, such as: “MS-1. My Principal Investigator (PI)/advisor provides real mentorship”, “MS-2. My PI/advisor is an asset to my academic and professional career”, “MS-3. My PI/advisor provides ample support”, and “MS-4. My PI/advisor positively impacts my emotional or mental wellbeing”. Career Preparedness (CP) was measured by four items including: “CP-1. I am on track to complete my training”, “CP-2. I am well prepared for completing my training”, “CP-3. I am confident about my career prospects”, and “CP-4. I am prepared for my post-training career”. The Cronbach’s alphas for MS and CP are .864 and .905, respectively. In addition to these two primary measures, we also asked participants to report the use of the IDP (i.e., whether or not they completed an IDP annually with their PI/advisor). Other individual demographic information was collected and treated as covariates, such as gender, doctoral student/postdoctoral trainee, race/ethnicity, and citizenship status. The survey questionnaire and data set are freely accessible online.^{26,27}

Analytic strategy

To test the proposed conceptual models shown in Figure 1, this study employed the design-based multilevel structural equation models^{28,29} by using Mplus 8.6.³⁰ This approach allows us to test the interrelationships among the variables simultaneously, handle the measurement error issue, and correct the underestimated standard errors due to the nested data structure (students clustered with institutions). Other open-source software like the *lavaan.survey* package in R could be also used to conduct the same analysis.³¹

The models not only highlight the primary variables (IDP, mentoring support, and career preparedness), but also consider that the individual background characteristics are functioning over the process. In the analysis, for each primary variable, we also controlled for gender (female = 1; male = 0), doctoral student/postdoctoral trainee (postdoctoral trainee = 1; doctoral student = 0), race/ethnicity (Black/Hispanic/Native Americans = 1; the rest of racial groups = 0), and citizenship status (international scholar = 1; citizen or permanent resident = 0). The final Mplus code and the data set we used for the analysis can be accessed at an online data repository.³²

Results

Sample characteristics and descriptive results

Among our sample (N = 660), 22% were postdoctoral researchers, 74% were female, 10% were underrepresented minorities (i.e., Black/Hispanic/Native Americans), 10% were international students/researchers, and 39 % reported they completed an IDP annually with their PI/advisor. The descriptive results for all measures and demographic information are shown in [Table 1](#).

In [Table 2](#), we describe the statistical differences of the IDP use, mentoring support, and career preparedness by trainees’ backgrounds. For example, postdoctoral fellows were less likely to use the IDP ($\beta = -.36, p < .01$) and received lower

Table 1. Descriptive results for all measures.

Variables	Mean	SD	Min	Max
IDP	0.39	0.49	0.00	1.00
Mentoring Support (MS)				
■ MS-1. My PI/advisor provides real mentorship	3.63	1.29	1.00	5.00
■ MS-2. My PI/advisor is an asset to my academic and professional career	4.00	1.09	1.00	5.00
■ MS-3. My PI/advisor provides ample support	3.60	1.22	1.00	5.00
■ MS-4. My PI/advisor positively impacts my emotional or mental wellbeing	3.24	1.22	1.00	5.00
Career Preparedness (CP)				
■ CP-1. I am on track to complete my training	3.88	0.98	1.00	5.00
■ CP-2. I am well prepared for completing my training	3.55	0.99	1.00	5.00
■ CP-3. I am confident about my career prospects	3.04	1.16	1.00	5.00
■ CP-4. I am prepared for my post-training career	3.11	1.05	1.00	5.00
Background Characteristics				
■ Female	0.74	0.44	0.00	1.00
■ Postdoctoral Fellow	0.22	0.41	0.00	1.00
■ Black/Hispanic/Native Americans	0.10	0.30	0.00	1.00
■ International Scholars	0.10	0.30	0.00	1.00

Note. N = 660, SD = Standard Deviation, Min = Minimum, Max = Maximum, IDP = Individual development plan.

Table 2. Standardized mean differences by background characteristics.

Background characteristics	IDP	Mentoring Support	Career Preparedness
Female			
(vs. male)	.02	-.01	-.13
SE	(.08)	(.10)	(.09)
Postdoctoral Fellow			
(vs. doctoral students)	-.36**	-.24*	-.27
SE	(.11)	(.10)	(.14)
Black/Hispanic/Native Americans			
(vs. other racial groups)	.07	-.03	.18
SE	(.17)	(.14)	(.15)
International Scholars			
(vs. citizen or permanent resident)	-.57***	.01	-.26
SE	(.14)	(.14)	(.14)

Note. N = 660, SE = Standard Error. IDP is an observed categorical variable. Mentoring support is a latent factor measured by four items (MS-1 to MS-4) shown in [Table 1](#). Career preparedness is a latent factor measured by four items (CP-1 to CP-4) shown in [Table 1](#). The difference test for each variable (i.e., IDP, mentoring support, and career preparedness) was examined by each background characteristic at a time.

* $p < .05$.
 ** $p < .01$.
 *** $p < .001$.

mentoring support ($\beta = -.57, p < .001$) compared with doctoral students. International scholars were also less likely to use the IDP ($\beta = -.24, p < .001$) than scholars who were citizens or permanent residents of the United States.

IDP as a key factor for mentoring support and career preparedness

The statistical results indicate that model 1 adequately fits the empirical data: Root Mean Square Error of Approximation (RMSEA) = .034; Comparative Fit Index (CFI) = .965; Standardized Root Mean Squared Residual (SRMR) = .031. As shown in Figure 2, the standardized factor loadings in the model are all greater than .70, indicating good measurement validity for constructing the latent factors (mentoring support and career preparedness).

Controlling for the individual background characteristics, the results in Figure 2 reveal that the IDP shows positive effects on mentoring support ($\beta = .27, p < .001$) and career preparedness ($\beta = .17, p < .01$); at the same time, mentoring support is also a mediator between the IDP and career preparedness. These results suggest the use of an IDP could enhance a mentee’s career preparedness through mentoring support. However, we find that postdoctoral researchers ($\beta = -.37, p < .001$) and international scholars ($\beta = -.59, p < .001$) were less likely to use the IDP annually with their PI/advisor. Females had lower career preparedness ($\beta = -.13, p < .05$) than males, but there are no significant differences among racial groups in the use of IDP, mentoring support, and career preparedness.

Overall, the use of the IDP, mentoring support, and background characteristics can account for 26% of the variance in career preparedness. The use of the IDP and background characteristics can explain 8% of the variance in mentoring support. The background characteristics can account for 5% of the variance in the use of the IDP. The unexplained variances imply that there are other unknown contributing factors also relating to these three primary variables.

Mentoring support and career preparedness as motivations for the use of IDP

The statistical results indicate that model 2 also adequately fits the empirical data (RMSEA = .034; CFI = .965; SRMR = .031). In Figure 3, the standardized factor loadings in the model also show good measurement validity for constructing the latent factors (mentoring support and career preparedness).

Over and above the background characteristics, the results in Figure 3 indicate that mentoring support has a positive effect on career preparedness ($\beta = .46, p < .001$), while both mentoring support ($\beta = .17, p < .01$) and career preparedness ($\beta = .19, p < .01$) positively predict the use of the IDP. Multiple significant paths from background characteristics to three primary variables provide additional warnings. We found that the lower mentoring support ($\beta = -.23, p < .05$)

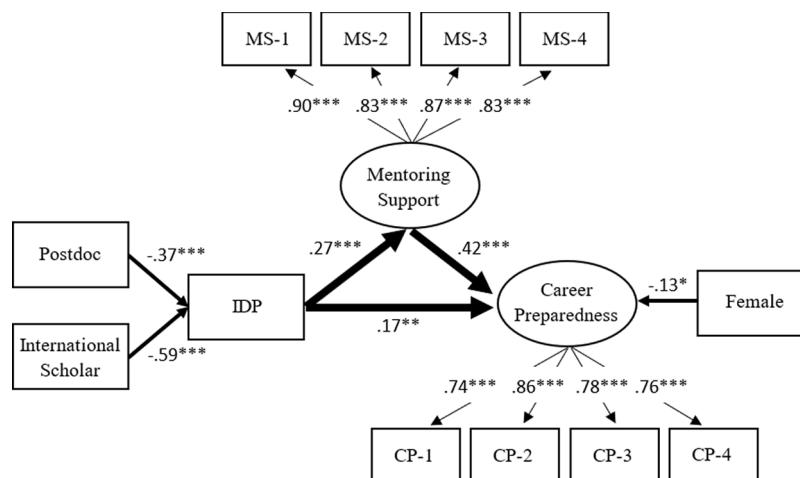


Figure 2. Model 1: Individual development plan (IDP) as a key factor for mentoring support and career preparedness. Note. Value is standardized path coefficient. The values on the light arrows are standardized factor loadings. Given that the use of the IDP is binary, the coefficients on the path from variables to IDP are standardized probit coefficients. The Primary variables (IDP, mentoring support, and career preparedness) are controlled by gender, doctoral student/postdoctoral fellow, race/ethnicity, and citizenship status. Only the statistically significant paths are shown in the figure. The reference group of the IDP is the trainee who did not use the IDP with their PI/advisor annually. The reference group of females is male. The reference group of Postdoctoral fellows is doctoral student. The reference group of international scholars is citizen or permanent resident. Oval represents a latent factor (measured by a set of indicators). Rectangle stands for an observed variable. MS-1 to MS-4 are the observed indicators of mentoring support, while CP-1 to CP-4 are the observed indicators of career preparedness. The full description for each of these indicators is shown in Table 1. * $p < .05$ ** $p < .01$ *** $p < .001$.

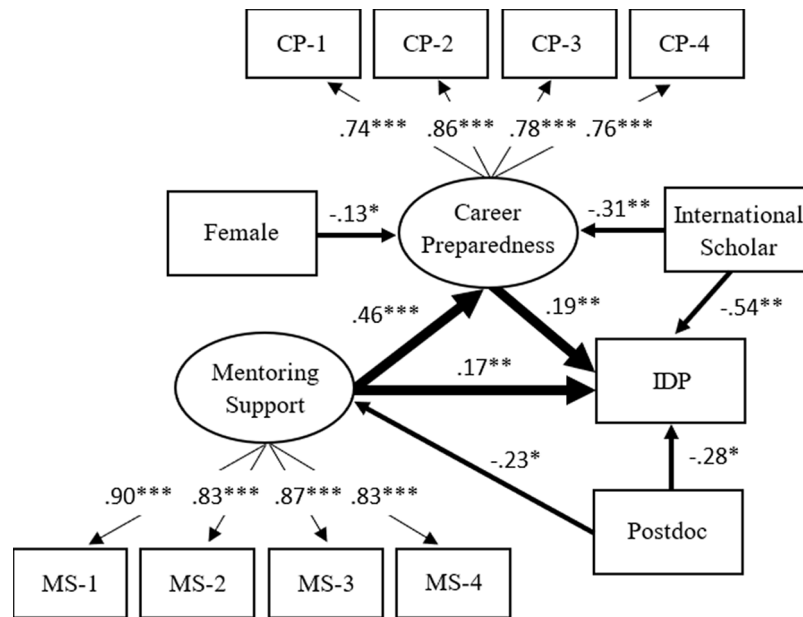


Figure 3. Model 2: Mentoring support and career preparedness as motivations for the use of individual development plan (IDP). Note. Value is standardized path coefficient. The values on the light arrows are standardized factor loadings. Given that the use of the IDP is binary, the coefficients on the path from variables to IDP are standardized probit coefficients. The Primary variables (IDP, mentoring support, and career preparedness) are controlled by gender, doctoral student/postdoctoral fellow, race/ethnicity, and citizenship status. Only the statistically significant paths are shown in the figure. The reference group of the IDP is the trainee who did not use the IDP with their PI/advisor annually. The reference group of females is male. The reference group of Postdoctoral fellows is doctoral student. The reference group of international scholars is citizen or permanent resident. Oval represents a latent factor (measured by a set of indicators). Rectangle stands for an observed variable. MS-1 to MS-4 are the observed indicators of mentoring support, while CP-1 to CP-4 are the observed indicators of career preparedness. The full description for each of these indicators is shown in Table 1. * $p < .05$ ** $p < .01$ *** $p < .001$.

for postdoctoral researchers might partially explain why they were less likely to use the IDP ($\beta = -.28, p < .05$). For international scholars, their lower career preparedness ($\beta = -.31, p < .01$) indirectly revealed why they used the IDP less than U.S. citizens or permanent residents ($\beta = -.54, p < .01$).

Overall, mentoring support, career preparedness, and individual background characteristics can explain 15% of the variance in the use of the IDP. The mentoring support and individual background characteristics can account for 24% of the variance in career preparedness. The individual background characteristics can explain only 1% of the variance in mentoring support. The unexplained variances mean that there are other unknown factors, which were not included and collected by this study.

Discussion

As greater career development support for doctoral students and postdoctoral researchers has been emphasized, the IDP has become a commonly used mentoring tool in science, technology, engineering, and mathematics (STEM) fields. Although this tool is encouraged, its effect on mentoring support and career development is still understudied. To fill the gaps, this study investigated 660 doctoral students and postdoctoral researchers in the life sciences to test the two conceptual models by using the design-based multilevel structural equation models. The empirical evidence supports the two proposed conceptual models and connects the relationships among the use of the IDP, mentoring support, and career preparedness.

In the first model, we found that using the IDP can enhance mentoring support and career preparedness; meaning, greater mentoring support and higher level of career preparedness. Our findings affirm the IDP in practice, joining other IDP research^{20,21,24,33} that encourage mentees to utilize the IDP to self-assess current skills and create a strategic plan with their mentors. Mentor and mentee continually prioritize and revisit the IDP to track progress and refine objectives, whereby mentees eventually achieve their career goals with mentoring support. In the second model, our finding aligned with previous research^{20,21,24} and extends the evidence that greater mentoring support and career preparedness are associated with the use of the IDP. Although the reasons remain unknown and possibly complex, our result is similar

to Hobin's research finding that career development discussions between mentors and postdocs are often absent or lacking,²⁰ or 'underutilized'.³³ Given that an IDP can establish a long-term mentorship, it is not surprising that mentees will continually hold IDP discussions with their PI or mentor when they perceive a need for mentoring support and get closer to their career goals. Recent IDP research provides evidence for enabling a customized or flexible IDP implementation process that promotes a learner-centered approach and aligns with current higher education aspirations.³³

This study also examined how individual background characteristics were functioning over the process. Although our results provide evidence for how the IDP and mentorship can encourage career preparedness, female trainees showed a lower career preparedness than males. Females have historically experienced notable and significant STEM challenges, such as negative stereotypes, hostile environments, and developing trainee identity.^{34–36} Recently, mentorship was discovered to predict high levels of gender-STEM identity for women.³⁵ Aligned with an ever-increasing (and needed) higher education movement at National Institute of Health (e.g. BEST, Common Fund, T32) and National Sciences Foundation (e.g., NRT, Louis Stokes, AGEP), we recommend that institutions and faculty members should pay more attention to female scholars. Specifically, we suggest continued reduction of the STEM barriers and negative stereotypes for women, and expanded mentorship to underrepresented students in career preparedness skill development that enables a student's transition into wider range of STEM-related careers.^{17,25,33,37} Additionally, the results reveal that international scholars and postdoctoral researchers were less likely to use the IDP. The lower career preparedness for international scholars and the lower mentoring support for postdoctoral researchers might explain why these trainee populations used the IDP less than their counterparts. We encourage their PIs or mentors to use some well-established IDP platforms (e.g., myIDP) to identify their career goals and create action plans every year. We also recommend that mentors provide a safe and welcoming atmosphere where career preparedness discussions are the norm, not the expectation, even if that means more faculty mentoring development is needed.^{20,21,25}

While our findings show important implications for the IDP research, there are still several limitations to this study. First, the data collection (summer 2016) may be considered dated. However, our research goal was to examine the effect of the IDP. We believe it is still acceptable to use the empirical evidence to test our conceptual models. Second, even though we identified the interrelationships among the use of the IDP, mentoring support, career preparedness, and individual background characteristics, there might be other unknown factors omitted from this study, such as the different types of IDP tools, the quality of IDP discussion, etc., which could be investigated in the future studies. Third, the present study was cross-sectional and not able to properly infer the longitudinal effect of the use of the IDP. Finally, although our sample is not nationally representative, our survey sample included a diverse group of doctoral students and postdoctoral researchers in the life/biological/medical fields from 91 institutions.

Despite these limitations, this study makes methodological and practical contributions to the literature on IDP and extends the scholarship of mentoring.²⁵ First, it is one of first empirical studies to propose conceptual models for IDP research and examines the interrelationships among the IDP, mentoring support, and career preparedness with a diverse sample of doctoral students and postdoctoral researchers. Second, instead of using descriptive results to indicate the disparities of individual backgrounds in each of primary variables, this study showed how the background characteristics are functioning over the process. Third, and importantly, the findings provide the graduate and postdoctoral education community with empirical evidence and implications for the use of the IDP, as well as the need to improve mentor training.^{8,19–21,24} Incorporating these IDP models and evidence as part of doctoral, postdoc, and early career faculty orientation would promote high quality mentoring relationships from the beginning. In short, our study suggests that using the IDP could provide career development support for both doctoral trainees and postdoctoral researchers in the life sciences.

Implementation of IDPs to improve doctoral education, postdoctoral training, and faculty mentoring will produce diversity and flexibility through meaningful and transformative educational experiences for each trainee. Especially in the current COVID-19 context, these factors will be of vast importance for the future of our research and training enterprise. This research demonstrated the empirical evidence an IDP has within mentorship and career preparedness and offered further implications the IDP is an important career development tool that enhances trainees overall career preparation.

Data availability

Underlying data

Figshare: Modeling individual development plans, mentoring support, and career preparedness relationships among Ph. D. trainees in the life sciences. <https://doi.org/10.6084/m9.figshare.14893116.v1>.²⁶

Data are available under the terms of the [Creative Commons Attribution 4.0 International license](#) (CC-BY 4.0).

Extended data

Figshare: Survey Questions - Modeling individual development plans, mentoring support, and career preparedness relationships among Ph.D. trainees in the life sciences. <https://doi.org/10.6084/m9.figshare.14893182.v1>.²⁷

This project contains the following extended data: the questionnaire for this study.

Data are available under the terms of the [Creative Commons Attribution 4.0 International license](#) (CC-BY 4.0).

Software availability

Our analysis was performed by using the statistical software, Mplus 8.6. Archived Mplus code and data set at time of publication: <https://doi.org/10.5281/zenodo.5055803>.³²

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Jessica Kathleen Polka 

ASAPbio, San Francisco, CA, USA

Thank you for helpful responses. I have no further concerns.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Open science, scholarly communication, early career researchers

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Reviewer Report 20 December 2021

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Adriana Bankston 

University of California Office of the President, Washington, DC, USA

No additional comments.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Higher education policy

I confirm that I have read this submission and believe that I have an appropriate level of

expertise to confirm that it is of an acceptable scientific standard.

Version 1

Reviewer Report 11 August 2021

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Jessica Kathleen Polka 

ASAPbio, San Francisco, CA, USA

Note that I don't have adequate expertise to evaluate the structural equation modeling in this paper, hence my provisional approval.

In "Modeling individual development plans, mentoring support, and career preparedness relationships among Doctor of Philosophy (Ph.D.) trainees in the life sciences," Chang *et al.* analyze data from a survey of doctoral students. The design of the survey appears sound, and the resulting data enable the authors to draw valuable conclusions about IDP usage, its relationship to demographic variables, and its correlation with mentoring support and career preparedness.

My most substantial questions surround the use of structural equation modeling, which I lack the expertise to adequately assess. I believe this work should be reviewed by an expert in that area. Nevertheless, a few issues arose for me:

1. The statistical results are identical for both models. Does this mean that one model cannot be favored over the other, and thus, that the causal relationships can be described as a positive feedback loop, with IDP usage supporting career preparedness & mentoring support, and vice versa? Is it then possible to represent such a circular relationship in a new model, and would such a model fit the data better?
2. Why are arrows between career preparedness & mentoring support not bidirectional in both cases? For example, imagine the trainee has good career preparedness from other sources (peers, society, internet resources, institution, etc) and has therefore selected a mentor on the basis of their support, or is therefore proactively seeking mentorship.

I also have a few more minor points:

1. In the "Conclusions" section of the abstract, I'm not understanding the first part of the sentence, which states that evidence is demonstrated but does not seem to specify the conclusion.
2. In Methods (Data/sample) - "Survey invitations were distributed via direct email to randomly chosen United States (U.S.) institutions with graduate-level programs," where were these email addresses found? Do these represent emails of graduate program coordinators, or students themselves, as implied in the following sentence?

3. In Results, the sentence beginning "With regard to individual background" could perhaps be more logically presented in a separate section about the survey responses independent of the two models.
4. Throughout the text, proofreading could help to improve readability.

Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Partly

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

I cannot comment. A qualified statistician is required.

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Open science, scholarly communication, early career researchers

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 13 Dec 2021

Clint Patterson, Texas A&M University, College Station, USA

Thank you for the feedback and review of our study. We appreciate your perspective, questions, and recommendations.

We appreciate the reviewer's question about the model fit issue. For the first question, in SEM, changing the direction of one or more paths in a model will yield an equivalent model. Equivalent models will result in precisely the same model fit. That is why our two models showed the identical model fit results (RMSEA = .034; CFI = .965; SRMR = .031). Therefore, we are not able to evaluate if one model was favored over the other, which was also not the purpose of this study. Our goal was to test if 1) the IDP enhances an individual's mentoring support and career preparedness, and 2) mentoring support and career preparedness

predict the use of IDPs. Each of the results showed the positive relationships among these three focal variables with a good model fit. For the second question, we could test a new model with a circular relationship, but the model fit will be the same given that we just change the direction of paths in the model. Therefore, we think our original models already show a good model fit to answer our research questions.

We appreciate reviewer's question and comments about the relationship between mentoring support and career preparedness. In this study, we considered mentoring support is one of the inputs for career preparedness (output), which was aligned with the mentoring literature (i.e., process-oriented model of mentoring; Eby et al., 2013). That was why we tested the path from mentoring support to career preparedness in both models theoretically. In practice, we agree that it is possible that trainees with good career preparedness proactively seek mentorship. To address the reviewer's concern, we conducted additional tests for models 1 and 2 by correlating mentoring support and career preparedness (bidirectional). In updated model 1, IDP showed significantly positive effects on mentoring support ($\beta = .27, p < .001$ vs. $\beta = .27, p < .001$) and career preparedness ($\beta = .28, p < .001$), while mentoring support and career preparedness were positively correlated with each other ($\beta = .43, p < .001$). In updated model 2, both mentoring support ($\beta = .15, p < .01$) and career preparedness ($\beta = .28, p < .01$) positively predicted the use of the IDP, while mentoring support and career preparedness were positively correlated with each other ($\beta = .38, p < .001$). The updated results were still very similar and consistent with our original findings, so we decided to keep our original models and results as is in the paper.

Thank you for the minor point about the "Conclusions" section of the abstract, which is now revised -- "This research offered empirical evidence for how an IDP, mentorship, and career preparedness interact. Findings revealed the IDP enhances mentoring support and career preparedness, as well as mentoring support and career preparedness predict IDP use. We conclude the IDP is an important mentorship tool that enhances trainees' overall career preparation."

We appreciate your point about the Methods (Data/sample). The data was collected using a sample of convenience. We included institutions that made emails publicly available on their websites. These emails could have included trainees and/or program leadership including program directors or coordinators. The study was promoted on Twitter and LinkedIn, and posts were shared widely by social media users.

Thank you for the feedback in the Results section. We ran an additional analysis to test the differences of each variable by background characteristics. This revised manuscript now includes an expanded "Sample characteristics and descriptive results" section and new Table 2 is included in this revised manuscript.

Thank you again for your article review and methodological questions. We sincerely appreciated the feedback and incorporated into what we believe is a stronger revision.

Competing Interests: No competing interests were disclosed.

Reviewer Report 02 August 2021

<https://doi.org/10.5256/f1000research.57120.r90084>

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Adriana Bankston 

University of California Office of the President, Washington, DC, USA

This study provides a robust characterization of the relationship between the IDP, mentoring support, and career preparedness for trainees, which is necessary for supporting graduate students and postdocs in universities. I agree with the characterization that, while this study is from 2016, the data are relevant for comparing these models and the study is valuable for the community to be aware of, and the conclusions are appropriate. The sample size and number of institutions examined also make this a robust study with important results for higher education.

The observation that the IDP is most effective when mentoring is positive and when trainees can engage in career development activities is an interesting one, which also extends to questions related to how mentoring relationships could be improved and what systemic changes need to occur in order for career development activities to be more accepted and included into the training of graduate students and postdoctoral researchers as important components to prepare them for skill building and future jobs. For example, a recent study from PLOS Biology (Brandt *et al.*, 2021) showed that involvement in career development activities for PhD students is not detrimental to their research productivity.

To this end, it was disappointing but informative to see that only 20% of mentors were familiar with the IDP process, and that in many cases mentees completed them but did not discuss them with mentors. To an extent, I agree that the mentee needs to take charge of their professional development and make sure to complete the IDP and take the initiative to set up meetings with their mentor to discuss results. But this also points to the fact that we need to incentivize a higher number of mentors to learn about the IDP, think about how institutions can assist with this goal, and whether there are positive model institutions where this occurs regularly to be used as a model for others. I'm not sure what is currently being mandated by institutions across the country in terms of the IDP. A good discussion point in terms of future directions would be to talk about incentives for mentors to use the IDP for supporting their mentees in their career development and whether institutions can put in place a reward system for those that show consistently positive results in order to improve the enterprise as a whole.

Indeed, the report suggests that only 39% reported that they completed an IDP annually with their mentor, which isn't a very high number considering the number of graduate students and postdocs we are training in our universities. Moreover, it seems that postdocs and international trainees aren't using the IDP as much, which is also unfortunate to see. One question for discussion would be to think about what kind of support for career development graduate students need, which may be different from those of postdocs, and how the IDP may potentially be adapted to better suit these needs in the future. In addition, we know that international

researchers typically receive less career support, and I would be curious to explore this more as to whether they use the IDP less due to language barriers or other factors that may make them feel uncomfortable to discuss career options with their mentors. Given the importance of international trainees for advancing research forward and the high percentage of the research workforce that is foreign-born with U.S. laboratories, it would be important to address how we can support them more in the discussion section.

In terms of the survey results, I was wondering if there were any negative answers given on mentoring (or if that was an answer option) and whether trainees felt that lack of mentoring led to them feeling less prepared for a particular career path. This type of analysis could be a useful impetus for discussing systemic changes that need to occur to better support mentees, both from the perspective of the mentors and the institutions. This question could be a follow-up study to look at systemic issues and solutions to address them.

I appreciated the remarks made in relation to IDP and long-term mentorship, as I think it's useful to think about how often mentees approach their mentors about career goals and making sure that these conversations occur at regular intervals throughout their training. It would be useful to do a study on how often meetings between mentors and mentees related to professional and career development typically occur in universities. Given that career goals can change, I would argue this needs to occur more frequently than once a year. A longitudinal study of career development discussions that occur at various timepoints during the training of a graduate student or postdoc could be very informative.

One question I had is whether the study results represent only STEM graduate students and postdocs, or whether they are specific to life sciences (which is more a subset of STEM). I would suggest clarifying this information in the methods section. I would also like to know more about the list of disciplines that were analyzed in the survey (if beyond STEM), and whether humanities and social sciences trainees responded differently to the survey questions as compared to those in STEM. The latter could provide useful insights into the effectiveness of the IDP.

I would have also liked to see a breakdown between data at particular institutions, in terms of whether these mentoring relationships and consequent IDP discussions are better or worse at R1 institutions versus those that are less research intensive, such as MSIs and HBCUs for example.

It may be interesting to survey the same population again now, in 2021 to assess pandemic impacts on the factors examined in this publication. The pandemic is likely to alter the dynamics between mentors and mentees. I would be curious to know if a higher number of trainees are completing the IDP since they are working from home using their computers. Also, if they are less able to perform bench science under the current circumstances, has this led to trainees focusing more on their career development during the pandemic and what lessons can we learn from this?

I would like to see more of discussion on diversity aspects of this study and how different ethnic groups used and/or benefitted from the IDP (for example BIPOC, LGBTQ etc. if these options were included), as well as how these variables intersect. For example, was there a difference between the career support that female graduate students received versus female postdocs, knowing these needs may be different? What about women of color at both career stages? It would be important to discuss more details about how this kind of career advice occurs and develop some recommendations for institutions to implement programs that may address these issues for

particular populations.

Finally, I thought the models proposed were interesting and thought provoking, as well as important for explaining this complicated dynamic. But I would consider a third model, where institutions also play a role, because institutional policies may dictate how some of these interactions take place. For example, the model could be Institutional support -> mentor support -> IDP -> career preparedness, or Institutional support -> mentor support/IDP as parallel tracks -> career preparedness. In this case, mentoring and IDP could both help with career development, where mentoring either encourages the IDP or could be parallel to it, but both are dictated by institutional policies. In a systemic sense, I think it's worthwhile considering how institutions can better incentivize mentoring and career development. Future surveys could include questions on how institutions should help graduate students and postdocs with career preparedness in addition to individual mentors, as well as how we can better prepare mentors to provide the necessary advice and guidance to their trainees.

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Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

Yes

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Higher education policy

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Author Response 13 Dec 2021

Clint Patterson, Texas A&M University, College Station, USA

Thank you for the review. We do agree with all the comments and wish to communicate your critique has been helpful as we revised the article. We are noting:

Much of your feedback points to an excellent framework for future mentorship research, which we believe is important for future directions of mentoring. For example, you identified good discussion points about incentives for mentors to use the IDP and how institutions reward or value IDPs in mentoring relationships. Additionally, negative answers given to mentoring, either as a response option or open-ended response, were not included in the collected data. However, we agree with your recommendation that this mentoring relationship theme poses an important follow-up or future line of inquiry. We do agree a follow-up study that investigates institutional systemic mentoring issues and solutions to address these issues is important to high quality mentoring relationships. Your discussion point about how the COVID-19 pandemic is impacting IDP usage, research productivity, and career development is important. We believe such research could offer valuable perspectives for mentorship and the ever-evolving future workforce needs.

The IDP is approached as a living document, and customizable in many ways, including what the mentee identifies as salient topic(s) at that moment, and which topic(s) they wish to share with their mentor(s). As such, identifying the career development needs of graduate students can be emergent and unique to the individual. We do note career development coursework is a growing and effective trend in graduate education ([source](#)).

In our data sample section, we stated we removed the participant responses from a non-life sciences perspective. Therefore, our sample is fully associated with life sciences. We agree that broadening this research to include STEM and non-STEM (i.e., humanities, social sciences) would offer valuable insights into IDP implementation and effectiveness. We reviewed the collected data and determined most institutions were not MSI and/or HBCU. Unfortunately, we do not have a large and diverse enough sample to appropriately answer if IDP usage differs at institutions (i.e., R1s, MSIs, HBCUs) but agree this would be an intriguing line of future research and findings could offer specific institutional implications for mentorship. Additionally, our study's variable was the biological gender. We recommend future studies that investigate how the IDP is incorporated and/or benefits marginalized populations (BIPOC, LBGTQ, etc.).

Lastly, your suggestion to make the institutional role more explicit with the models make sense; however, we do not have the data to support this recommendation. However, the idea aligns with two emerging notions in literature and is of interest for our authorship team. First, *The Science of Effective Mentoring in STEMM* (2019) reports institutions certainly influence the mentoring environment at their school, and even offered examples (including an IDP) for formalizing mentorship within and across the institution. Institutional approaches to mentoring are not only lines of inquiry, but also an implementation area, for some of our authorship team members. For example, the recent Transformative Doctoral Education Model (TDEM) explicitly recognizes the institution (including programs, mentors, and doctoral student) as an internal driver for the doctoral ecosystem.

Again, our thanks to the reviewer for their thoughtful feedback and insightful recommendations for this study and future IDP research considerations.

Competing Interests: No competing interests were disclosed.

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