

Investigating Experiences and Challenges of a Cohort of Interdisciplinary STEM Education through Collaborative Inquiry

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Abstract: This research paper examines the experiences of STEM education postdoctoral scholars, an understudied population in higher education that occupies a liminal space between student and faculty roles. Despite the increasing number of postdoctoral scholars in STEM education, postdoc responsibilities and challenges remain poorly defined in literature, particularly during the transition to full-time faculty positions. Postdocs face challenges unique from full-time faculty, including compensation and role uncertainty, which have been exacerbated in the current funding climate. Additionally, postdoctoral scholars' experiences in academia vary widely, which has contributed to their roles and responsibilities being poorly outlined in the literature. To fill these gaps in the literature, our study examines the responsibilities and challenges faced by a cohort of three STEM education postdoctoral scholars in their transition to full-time faculty and into more formal STEM education spaces. Specifically, our work answers the following research questions: What are the experiences of a cohort of interdisciplinary STEM education postdoctoral scholars regarding their 1) roles and responsibilities, and 2) the challenges they face in career development today. This study utilized a case study methodology embedded within a collaborative inquiry following three interdisciplinary STEM education postdoctoral scholars in their professional development. Informed by the Systems Theory Framework (STF) of career development, each scholar is represented through multiple lenses of influence on their self-concept as academics. The STF framework illustrates the diverse range of individual, social, environmental-societal systems, and their influence over each other with respect to career development. This case study leverages 12 months of weekly written reflections, memos, and weekly meetings to capture the postdoc experiences. The analysis focuses on professional responsibilities and challenges in the transition to their new roles through the STF, looking at personal, societal, and economic trends to understand their unique roles. Preliminary analysis of the artifacts suggests that postdoctoral roles and responsibilities can be broken down into two themes, academic research, including project development, theory, and grant writing, and professional development, which included mentorship, program management and teaching responsibilities. These roles intersect with some new-faculty roles, but without clear boundaries or delineations. Challenges faced by postdoctoral scholars were similarly broken down into three themes, 1) Navigating Competing Demands, 2) Relational Academic Spaces, and 3) Living and Working Under Constraint. Together, these themes highlight the uncertainty in postdoctoral roles and the need for institutional structures on postdoctoral affairs.

Introduction

Federal funding cuts have had widespread effects on academic communities, spreading uncertainty and fear in research institutions across the U.S. Amidst the current research funding crisis, academic postdoctoral scholars (postdocs) have fallen into a unique hardship. While academic jobs have been increasingly competitive in the United States, with the rate of PhD graduates far outpacing the tenure-track jobs available across STEM related fields, the current funding environment is predicted to exacerbate this trend, particularly for postdocs [1], [2], [3]. The National Postdoctoral Association reported that 54% of postdocs surveyed were impacted by these executive branch policy changes, with another 27% potentially impacted by funding cuts, anti-DEI action, program reduction, or other changes in federal research policy [4]. Furthermore, 78% responded that their job or position was threatened and/or their research was delayed by these changes, highlighting the affective toll that accompanied these changes. This troubling time highlights the need for more effective structural support for early career researchers in short term contracts.

Postdoctoral training can deepen training in academic research environments and support a future career in research [5], [6]. Postdoctoral fellowships in the US are considered “a temporary and defined period of mentored advanced training to enhance the professional skills and research independence needed to pursue his or her chosen career path” [7, p.1]. Postdocs’ roles and responsibilities vary widely though, from project management to experimental design and execution, the research field, the funding mechanism, and the research mentor’s needs all play roles in defining the scope of their work. Despite the growing number of postdoctoral positions in the US [8], scholarship on postdoctoral experiences is limited, particularly in social sciences and education [6], [9]. The existing literature paints a dire portrait of underpaid, overworked, and often overlooked scholars [10]. However, the current research environment calls for a deeper look into the challenges and responsibilities postdocs exhibit.

To better support the next generation of scholars, it is necessary to understand their roles and the specific challenges they face at this moment. In this paper, we utilized a collaborative inquiry as a lens to explore how STEM education postdoctoral scholars experience their roles, what their roles entail and how they are impacted by their individual, social, and societal systems through our own experiences. To understand the scope of our roles over the course of a yearlong fellowship and the challenges therein, we explore the following research questions:

1. *What do postdoctoral scholars in STEM education do in a program designed to support their career development? What are their roles and responsibilities? Who sets them?*
2. *What challenges do postdoctoral scholars in STEM education encounter in their work? Where do the challenges originate?*

To answer these questions, we utilized a thematic coding process to analyze weekly reflections that were answered across 2025. Our results highlight the breadth of roles that we took on as postdocs, including advancing numerous research projects, teaching, project management, and

various forms of individualized professional skills development. We also identified three emergent challenges that we faced in the postdoctoral scholar role, namely: 1) Navigating Competing Demands, 2) Relational Academic Spaces, and 3) Living and Working Under Constraint. This study contributes to the body of relevant research by further expounding the breadth of roles and responsibilities that STEM postdocs develop as well as the internal and external influences that can inhibit professional development.

Literature Review

2.1 Post doctoral Professional Development: Skill-Building and Competency Development

The postdoctoral appointment is commonly described in the literature as a critical period of professional skill development that extends beyond disciplinary research training [11], [12], [13]. Studies indicate that postdoctoral scholars are expected to expand their methodological and analytical competencies while simultaneously demonstrating increasing research independence [14], [15]. Within STEM education contexts, this often involves engagement with interdisciplinary research approaches and educational inquiry that differ from prior doctoral training. However, opportunities for skill development are uneven and frequently shaped by local mentoring practices and institutional environments, requiring postdoctoral scholars to navigate professional growth with limited formal guidance [16].

In addition to research-related competencies, postdoctoral scholars are routinely engaged in leadership and professional activities that parallel early faculty responsibilities. Studies show that postdocs often contribute to project coordination, supervision of students or staff, and contributions to research planning, despite the absence of consistent training structures to support these roles [14], [16]. Furthermore, the scope and quality of these experiences vary widely across institutional contexts and mentoring relationships [16]. Transferable professional skills, including scholarly communication, time management, and preparation for externally funded research careers, are similarly consistently emphasized as central to postdoctoral success, particularly in competitive academic labor markets [17]. Collectively, these findings suggest that skill-building during the postdoctoral period is shaped by interacting individual and institutional influences, where there is a dynamic interconnected interplay of personal, social, and environmental systems shaping career development.

2.2 Postdoctoral Professional Development: Research Productivity and Scholarly Output

Research productivity has been consistently identified as a primary indicator of postdoctoral success and readiness for academic advancement [18], [19]. Specifically, expectations surrounding peer-reviewed publications, grant proposal development, and conference participation have been found to strongly shape postdoctoral experiences and career trajectories [14], [17]. For interdisciplinary STEM education postdocs, these expectations are often complicated by the need to publish across multiple scholarly communities, each with distinct norms and evaluative standards. There is ambiguity around these productivity

expectations, which can contribute to heightened uncertainty and pressure, particularly during periods of constrained funding or institutional instability [15], [16]. These pressures point to the importance of examining the academic structures that shape postdoctoral work.

Professional and mentoring structures also play a central role in mediating research productivity outcomes. Mentorship quality, collaborative authorship, and access to feedback are key in supporting publication output and career planning [14], [16]. Strategic research planning, such as setting early publication goals and aligning projects with longer-term career objectives, has been associated with greater clarity in postdoctoral trajectories [15]. At the same time, structural mentoring barriers and differential access to formal mentorship training can shape the quality of their research experiences and career development opportunities [16], [20]. This documented variability in mentoring practices and institutional support underscores the uneven conditions under which postdoctoral scholars pursue scholarly output. Overall, these patterns further reinforce the relevance of a systems-based framework for examining how individual agency, workplace relationships, and broader academic labor conditions jointly shape postdoctoral professional development experiences.

2.3 System Theory of Career Development

To systematically synthesize the challenges we face during our tenure as postdoctoral scholars, we have examined our work through the lens of the Systems Theory Framework (STF) for Career Development. Depicted in Figure 1, the STF synthesizes key factors identified across other career theories influencing career development. Influences are organized into content and process influences. Content influences are further categorized into three groups: a) individual influences including beliefs and age, b) social influences including peer groups and the workplace, and c) environmental/societal influences including historical trends and employment market. The three levels of content influences are illustrated in the framework as concentric circles with individual influences at the center and social and societal/environmental influences surrounding. Social Influences straddle the individual and environmental/societal circles, noting their bridging role. Process influences are noted in the framework through three primary methods, namely, change over time, chance, and recursiveness. The process influences described in the STF demonstrate influences can synergistically shape an individual's career aspirations and trajectory [21].

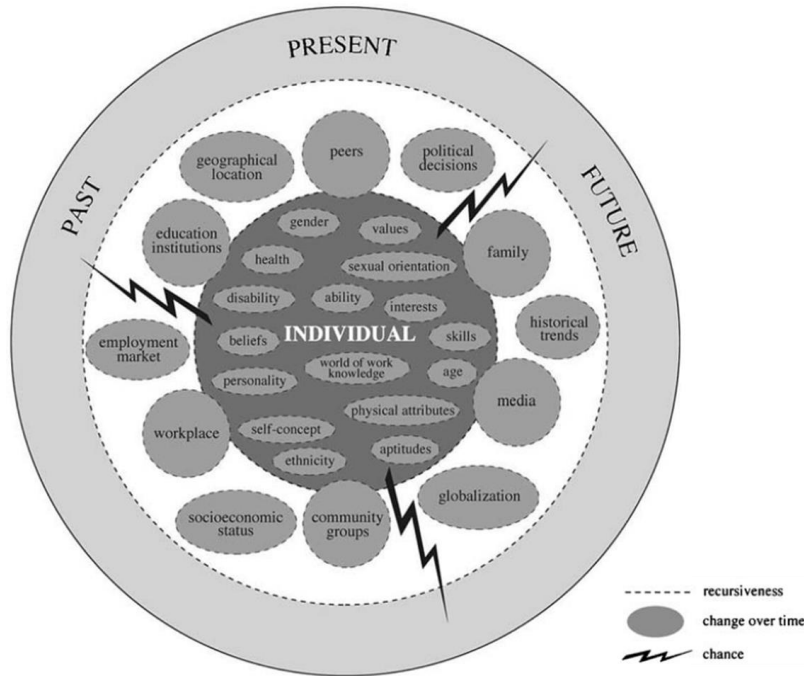


Figure 1. The Systems Theory Framework of Career Development from Patton and McMahon (1999)

The STF has been used to examine a breadth of influences on career aspirations and trajectories for many populations. A study examining career aspirations of Master’s engineering students emphasized the importance of fostering self-belief in their development of professional skills as a key factor over their career aspirations [22]. Researchers have examined the career-life planning for female, immigrant undergraduates, highlighting the difficulty of balancing multiple roles and family expectations as key influences [23]. The STF has similarly been used to examine the career aspirations of other populations, including first-year biosystems engineering undergraduates [24], medical professionals [25], and high school students [26]. As our research goals are similar to the aforementioned studies, we similarly leveraged the STF. However, the STF of career development and career theories at large have not been applied to postdoctoral career development and have led to a limited understanding of how socioeconomic systems impact career trajectories of these early career academics [27]. Our research aims to apply the STF of career development to our experiences as postdoctoral scholars to examine the role of individual, social and societal influences during a year-long period.

Methods

3.1 Collaborative Inquiry

This study is part of a larger NSF sponsored grant entitled, “Working Across Boundaries through promoting collaboration and interdisciplinarity in future STEM education scholars.” The broader grant created a cohort of three interdisciplinary STEM education postdoctoral scholars

and supported them through research, professional development, and mentoring activities. We, as the three members of the cohort, leveraged the support of the grant and a constellation of mentors to investigate our own professional development through a collaborative inquiry method. Collaborative inquiries provide a systematic, iterative process for a community of practice to reflect and evaluate problems [28], [29]. Additionally, collaborative inquiries promote collective sense-making, which enabled us to grapple with the complexity and liminality of our own postdoctoral development [30], [31].

3.1 Positionality Statement

As both researchers and participants in the collaborative inquiry, reflexivity was essential to negotiating methodology and ensuring equitable participation and analytical rigor [32]. Each of us entered the collaborative inquiry as recent PhD graduates from different fields—engineering education, biology, and chemistry. Due to the small size of the cohort, we chose to not disclose additional demographic factors and reported all quotes as part of a collective voice, because we believe the findings point to trends aligned with external factors, rather than identity work. With differing levels of exposure to STEM education research, we each sought different learning experiences and types of mentorships from the postdoctoral experience. Given our breadth of education research experience, we chose to focus on written reflections to give equal weight to each member's voice and report quotes as a part of a collective voice, rather than attribute them to one individual. To ensure analytical rigor, we coded each other's reflections, relying on the other members of the team to clarify any project specific language, and discussed any discrepancies in interpretation as a collective until consensus was reached.

3.3 Data Collection

Data for this study was collected as a part of the collaborative inquiry, for which data collection included weekly reflections, monthly reflections, and yearly reflections. The questions for the weekly reflections were designed by the members of the collaborative inquiry and adapted from the work of Coso-Strong and colleagues [31] on early career faculty navigating academia. To answer our research questions, we examined a subset of the weekly reflections ranging from January – November of 2025.

This study examines the specific questions examining the responsibilities (“What did you spend your time doing this week?”) and challenges (“What is/was a challenge?”) that we faced throughout the week. Other questions of the weekly reflection included discussion of support systems, expectations for the following week, and affective notions about the prior week. The full list of weekly reflection questions can be found in Appendix A.

3.4 Thematic Coding Process

The analysis for this study was informed by Braun and Clarke's [33] thematic coding process (Figure 2). As a collaborative inquiry, the reflective data analyzed in this study were also generated by the research team, as their own weekly reflections throughout a year of their postdoc. However, to ensure that we were familiar with the full dataset, and not just our own

quotations, all three authors reread and created cursory memos for all the excerpts. After familiarizing ourselves with the full dataset we generated a list of initial codes along two parallel tracks, each associated with a different research question (Figure 2). We utilized an inductive coding process to create a list of codes for RQ1 (What do postdocs do?) and a deductive coding scheme, generating codes for RQ2 (What challenges do postdocs face?) informed by the STF of Career Development [21]. For RQ1, we identified codes such as ‘grant writing,’ teaching responsibilities,’ and ‘professional learning.’ We then searched for themes among the codes, settling on the themes ‘Academic Research’ and ‘Professional Development’ for RQ1. After creating and reviewing our initial themes, themes such as ‘Professional Learning’ and ‘Being Mentored’ emerged through the process. Finally, we further refined our theme names and definitions, resulting in the two codebooks depicted in the following section. Frequency coding from the qualitative themes was used to inform the theme names and framework alignment discussed in sections 4.1 and 4.2. Our methodological process is depicted below in Figure 2, which separates our dataset into two categories based on their affiliated research question, creates themes and analyzes the data independently, and brings the full dataset together when writing the report.

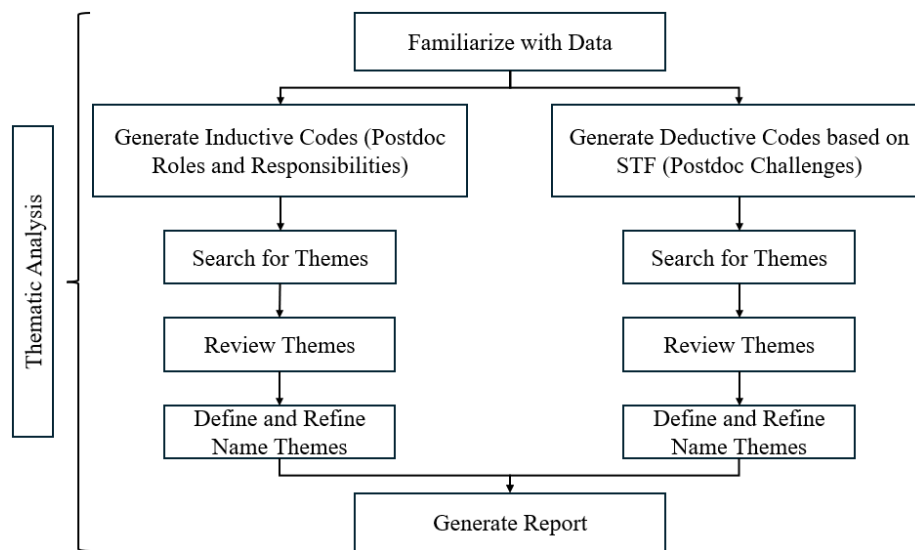


Figure 2. Adapted Thematic Analysis Process adapted from Braun and Clarke (2006)

Results & Discussion

4.1 Roles & Responsibilities

Through thematic analysis, we developed two primary themes: ‘Academic Research Development’ and ‘Professional Skills Development’ (Table 1). The themes mirror prior research that distinguish skill development as academic researcher focused roles and broader transferable skills required by postdoctoral scholars who cannot find homes in academia [34], [35]. Additionally, despite taking an inductive coding approach to examine the roles and

responsibilities of postdocs, we find our thematic codes similar to those of other research framework such as Nowell and colleagues' [35] Professional Learning and Development Framework for Postdoctoral Scholars and the Vitae Researcher Development Framework [36], which add to the relevance of our findings.

Table 1. Inductive thematic coding of postdoctoral roles and responsibilities

Inductive Coding for Roles			Code Frequency			
Primary Themes	Secondary Themes	Definition	Postdoc 1 (n=37)	Postdoc 2 (n=44)	Postdoc 3 (n=43)	Total
Academic Research Development	Project Development	Developing or furthering our own research (analysis, writing, collecting data, WAB meetings)	28	27	26	81
	Theory	Learning about or applying theory	7	4	7	18
	Grant Writing	Developing or supporting grant writing	6	0	1	7
Professional Skills Development	Mentoring	Supporting undergraduate or graduate students	4	13	23	40
	Being Mentored	Being supported by a PI or a faculty mentor	1	4	6	11
	Teaching Responsibilities	Guest lecturing or serving as primary instructor for a course	0	0	15	15
	Program Management	Supporting existing funded research, primarily through administrative tasks (i.e. emails and meetings)	8	16	15	39
	Professional Learning	Developing skills and knowledge outside of traditional research activities, (i.e. taking classes, workshops, external fellowships, leadership, conferences, and networking)	16	29	21	66
	Job Search	Developing documents and applying for jobs	0	1	3	4

n = Number of Weekly Reflections

The two most prevalent themes that emerged across all three cohort members were Project Development and Professional Learning (Table 1). Across our 124 weekly reflections, 81 (65%) included project development in part. The activities highlighted in reflections included: advancing doctoral research, joining mentors' research, and creating research projects with peers outside of our home departments and institution. These results are consistent with prior work that emphasizes postdoctoral scholars' priority on research development as a perpetuation of postdoctoral expectations to pursue academic roles [18].

The second most prevalent code that we identified in our weekly reflections was Professional Learning, which was coded 66 (53%) times across the 124 reflections (Table 1). We define Professional Learning as the development of professional skills and knowledge outside of traditional research activities. Within this study, professional learning activities included auditing graduate level classes, attending university-sponsored workshops, creating and hosting a university-wide postdoctoral research symposium, attending disciplinary education conferences, serving on disciplinary academic committees, and applying for external fellowships. The variety of professional learning activities that we explored emphasizes the breadth of activities that

postdoctoral scholars leverage to develop themselves professionally outside of academic research. Our findings are corroborated by the work of Nowell et al. [11], who found that postdoctoral scholars seek opportunities to support a plethora of skills, despite the priority of research output in academic promotion and tenure practices [11], [18].

While project development and professional learning remained the two most frequent themes across the cohort, responsibilities such as mentoring, teaching responsibilities, and program management varied across our cohort. Two of us took on larger mentoring roles, with one focusing more on graduate student mentorship with their PI's research group, and the other supporting undergraduates in collaborative research efforts. One team member joined the cohort with more teaching experience than the other two, which led to them not taking on an instructor role during the postdoc. This finding aligns with the work of Nowell et al. (2018), who emphasizes that one of the most desired areas of development for postdocs is teaching and learning skills [11]. This work also demonstrated the breadth and personalization that professional development efforts should encapsulate to support postdoctoral scholars as we all entered with different career trajectories and prior experiences [35].

4.2 Challenges

From our analysis of the challenges we faced each week, three themes emerged: 1) Navigating Competing Demands, 2) Relational Academic Spaces, and 3) Living and Working Under Constraint, which speak to the individual, social, and societal systems of STF respectively (Table 2). The theme 'Navigating Competing Demands' refers to instances of balancing multiple projects, roles, or responsibilities within the scope of work, and it encompasses individual skills such as time management and wellness practices. 'Relational Academic Spaces' refers to the social environment of the workplace, including interactions with peers, groups within their academic community, and the education institution at large. Finally, the 'Living and Working Under Constraint' theme includes reflections focused on the world around the individual, including political and economic factors that impact the postdocs and our families' physical and mental health. The interaction of each system of influence in our career paths became evident as our postdoctoral appointment progressed over the yearlong study, with societal changes deepening the complexity of our individual and social lives.

Table 2. Deductive thematic coding of postdoctoral career trajectories based on the Systems Theory Framework of Career Development

Deductive Coding for Influence over Career Trajectories based on the Systems Theory Framework of Career Development		Code Frequency			
Primary Theme (Definition)		Postdoc 1 (n=37)	Postdoc 2 (n=44)	Postdoc 3 (n=37)	Total
Individual Influences (influences pertaining to the one's own characteristics)	Health : Physical health	3	12	1	16
	Beliefs : Self-efficacy	4	0	2	6
	Mental Health : Psychological well-being	3	9	5	17
	Self-concept : Who you think you are, or want to be	3	1	4	8
	Ethnicity : Ethnic character, background, or affiliation	0	0	0	0
	Skills : Specific, long term (time management)	9	2	9	20
	Interests : Desire to do something	10	1	0	11
	Ability/ Capacity : Temporary capacity (temporal)	17	12	8	37
	Values : Moral or ethical commitments	1	1	3	5
Social Influences (influences pertaining to groups, often that the individual is a part of)	Peers : Upper graduate students or cohort	4	1	0	5
	Family : People related to you	0	13	0	13
	Media : Information presented online	0	0	0	0
	Academic Community Groups : Organizations within or adjacent to academia	5	4	1	10
	Workplace : An individual's primary academic unit	0	2	0	2
	Education Institutions : Public higher education in large	0	4	1	5
Societal/Environmental Influences (influences pertaining to the world around the individual, often that they do not have control over)	Political Decisions : US or state political decisions	2	0	2	4
	Historical Trends : Prior trends	0	0	0	0
	Globalization : An interconnected economy	0	0	0	0
	Socioeconomic Status : Role of finances in geographic location	0	0	0	0
	Employment Market : Job search	1	0	1	2
	Geographic Location : Where you live	0	0	0	0

The theme ‘Navigating Competing Demands’ was described as individual skill deficiencies in time management or task prioritization, rather than structural challenges in our training. As described in the breadth of roles and responsibilities listed in Table 1, postdoctoral scholars in STEM education balancing many different roles and projects, not only in their current appointment, but through continuing work from their doctoral studies and in ideation for future grants. Moving between projects was consistently reported as a challenge for all three postdocs across the year of data collection and described in language connected to the individual system of the STF framework (Table 2). One member of the cohort captured the sentiment, stating:

I feel like there is suddenly a lot more on my plate than there used to be, and I am worried about my ability to get it done and balance moving all of the things forward that I want to.

Upon transitioning into more independent research as a postdoc, the increased scope of work—with project management in addition to research responsibly for multiple projects—led to us questioning our individual capacity, or even self-concept as researchers in an interdisciplinary space. As another postdoc explained:

I am struggling to balance getting all these projects done, papers written, and apply to jobs. I feel like my feet are in two different worlds- I am not fully in the education space or the STEM space.

Not only did they feel the demands of competing projects, but they also describe the additional challenge of existing between two areas of research: learning science/education and STEM disciplines. In straddling multiple disciplinary boundaries, they describe the process of developing expertise in multiple domains, leading to an increased cognitive load. This challenge of entering and establishing a disciplinary identity in an interdisciplinary field has been discussed by other DBER faculty [37], [38], [39], underscoring the need for targeted professional development for early career researchers who hold multiple professional identities. However, throughout the yearlong reflections, the challenge of navigating competing demands was consistently named as an individual failing, a lack of capacity or ability. Collective reflection enabled us to situate our challenges within the broader context of postdoc structural support and name a systemic need for better professional development around program and project management in academia.

The second theme, ‘Relational Academic Spaces’, aligns with the social sphere of influence in the STF (Table 2). While prior surveys on postdoc experiences have described a correlation between the culture/atmosphere of their workplace and life satisfaction [40], the absence of the social influence in the reported challenged by our postdoc cohort was striking. Relationships with mentors, academic community groups, and peers were rarely reported as significant challenges. Rather, these relational factors were integrated into the challenge of navigating competing demands and time management. This may be due to the unique nature of our work— which is primarily independently managed— compared to laboratory-based STEM disciplines. However, the degree to which relational academic spaces impacted their job progression is unclear from these reflections alone, but seems to be largely positive, as many of us named our collaborators as sources of support while describing a challenge.

Finally, ‘Living and Working Under Constraint’ was both implicitly and explicitly present in the challenges we faced as postdocs on a week-to-week basis and corresponded temporally to major changes in the political and economic environment in the United States (Table 2). All three postdocs alluded to the shifting research priorities, one saying, “*This is a hard semester, I am exhausted and have a lot of things going on that I am anxious over, I need more down time.*” Another postdoc expressed their frustration with the funding changes, stating, “*The political landscape is f-ed, and this research is on the shortlist to being cancelled.*” The third postdoc’s words summarized the overall sentiment:

It was a challenge to balance my feelings about the ever-shifting political climate and the need to look for other jobs —being in the present and being productive in the job I currently have and getting my life stuff done. It was hard not to be impacted by other people’s reaction to the political climate.

Changes to federal funding not only impacted our responsibilities, but also our mental health and capacity to plan career paths. While often attributed to individual influences or failings, i.e., “*I need more down time,*” emotional fatigue/mental health from societal influences affected our job satisfaction and career trajectories. One of us summarized the sentiment saying,

It was a challenge to move myself back out of the survival space and into the space of moving my work forward.

While we may not yet understand the full impact of grant termination in research, the toll of political shifts on early career researchers' productivity and well-being is being echoed in other research communities [41]. By leveraging STF for career development, we were able to identify the impact of the societal system on our own postdoctoral development. Our own mental health challenges and shifting career aspirations point to a worrying trend and suggest that targeted interventions may be needed to preserve the next generation of scholars. Afterall, in an atmosphere operating in “*survival mode*” and constant fear around research funding, it is challenging to ask postdocs to move forward with projects and career pathways that may cease to exist.

Implications and Conclusions

5.1 Institutional and Mentorship Implications

The findings of this study propose that postdoctoral development in STEM education is shaped by layered institutional, relational, and societal challenges. As the postdocs in this study, we navigate evolving roles, mainly building project development and professional learning within their schedules while facing interdisciplinary identity work challenges, and broader political and economic pressures. Institutions and mentors can therefore play a critical role in clarifying expectations, aligning responsibilities, and helping postdocs mitigate the broader challenges that shape their early careers [42], [43]. The structure and support that should be provided at the mentor and institutional level include clear communication [44], attention to interdisciplinary identity [45], reinforcing commitment to existing professional learning interests, and supporting scholars in planning their futures. These forms of support should be implemented without creating new obligations or expanding the nature of postdoc work, as they are meant to reduce the existing management-based complexity and rigorous demands of the role [20], [43].

Clear communication about expectations and responsibilities can help postdocs appropriately allocate their efforts across research, professional learning, and service [43], [46], [47]. To support this, institutions should clearly define potential roles for postdocs at the beginning of their position that distinguish among research production, professional learning, mentoring, teaching, and programmatic service. Once postdocs have the ability to structure objectives across a given timeline, mentors can then help formalize these development plans at the beginning of their postdoc's appointment to address required and personal priorities towards

career preparedness [48], [49]. The key to a successful development plan, however, happens only when mentors follow up on these plans to clarify primary objectives, expected outputs, and realistic benchmarks [50]. Postdoc roles expand and evolve throughout the short period of employment within a liminal space [51]. Due to the ever-evolving shifts that occur, it is important to calibrate postdoctoral workload periodically over time [27]. An action-based development plan should be prioritized with contract start and end dates and timelines added to major and minor goals [35], [52]. The plan should also identify current skills and available resources related to those goals, as well as identifying competencies and resources that mentors can help make accessible [52], [53]. Postdocs can also personalize the mentorship they receive by mentoring upward [54], [55]. By articulating their goals directly and requesting specific collaboration, publication, teaching, or service opportunities, mentors can more effectively align support with evolving development plans [54].

The interdisciplinary positioning described in this study also warrants intentionality in mentorship guidance. Our reflections show that we are consistently negotiating expertise across STEM and education, increasing our cognitive load and developing uncertainty about professional positioning. In response, mentors can take an active role in building intellectual bridges by introducing postdoctoral scholars to trusted colleagues whose expertise aligns with their interdisciplinary interests [14]. Direct email introductions, facilitated virtual meetings, and collaborative conversations can provide structured entry points into adjacent scholarly communities [56], [57]. Institutions can also complement these efforts by recognizing cross departmental mentorship as a meaningful contribution to postdoctoral training and scholarly advancement [58], [59], [60].

Professional learning activities are prominent in our reflections and can be acknowledged as an integral dimension of postdoctoral training. Each of us actively pursued workshops, conferences, committee service, and fellowship applications, signaling an understanding that long term career advancement requires more than research output alone. Mentors can help scholars identify connections between these activities and longer-term career goals, supporting deliberate choices about where to invest time and effort [59]. Actions by mentors that support professional learning interests can include thoughtful nominations for awards, direct email introductions to colleagues, and facilitated connections to conference or committee service [61], [62]. Such actions are most effective when grounded in consistent ongoing conversations that center the postdoc's interests and intended career pathways [16], [63]. Mentors can further demystify professional advancement by sharing their own job application materials and discussing their own professional experiences, enabling postdoctoral scholars to see how conference participation, committee work, funded projects, and other professional activities can be translated into compelling narratives for future applications [64], [65].

5.2 Limitations

This study was conducted within a federally funded context that intentionally supported collaboration, interdisciplinarity, and structured reflection among a small cohort of STEM education postdoctoral scholars, and these conditions shape the interpretation of our findings. The coordinated mentoring, professional development resources, and cohort-based model afforded a degree of flexibility and intellectual autonomy that may not reflect more traditional postdoctoral appointments organized around a single principal investigator or tightly defined grant deliverables. The prominence of interdisciplinary identity work and collaborative professional learning may be influenced by this structure. Additionally, although the grant provided flexibility, participants still faced broader structural challenges, including political and economic shifts and funding uncertainty. This combination of freedom in shaping our work and instability in the larger environment created a dynamic that may look different in other postdoctoral settings.

Relying on self-reported reflective data from three scholars who were simultaneously participants and researchers within the collaborative inquiry also introduces important considerations. Although systematic thematic coding procedures were employed, and each author engaged with the full dataset, the interpretive nature of reflective inquiry means that our perspectives inevitably shaped how experiences were documented and understood. As a result, the findings represent a contextually grounded depiction of postdoctoral development within a specific interdisciplinary grant structure rather than a broadly generalizable depiction of all postdoctoral experiences.

5.3 Conclusions

Our work suggests that postdoctoral scholars take on many roles within their work, including developing individual research plans, teaching, program management, and networking. In addition to the personal motivations, competing demands, and influences that directed our careers and professional development, we also emphasize the role of external influences such as the changing political landscape and evolving responsibilities as challenges for postdoctoral scholars. This study contributes to the body of relevant research by further expounding the breadth of roles and responsibilities that STEM postdocs develop as well as the internal and external influences that can inhibit professional development.

Future work will further explore the relationship between individual and external (social and societal/environmental) influences by examining the resources and support systems that the members of the cohort utilized during their postdoctoral fellowships. Additionally, we will more deeply examine the role of time as it pertains to both the roles we exercised across the postdoc and the challenges we faced. We also aim to expand this work to examine the relevant support systems and structures that enable us to navigate challenges within our postdoc experiences.

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Appendix A: Weekly Reflection Full Protocol

1. What did you spend your time doing this week?
2. What are you proud of this week?
3. What is something exciting from your work this week you learned/uncovered?
4. What was/is a challenge?
5. What resources/supports/opportunities did you tap into?
6. What parts of your identity did you feel like you were balancing?
7. What is something that you are excited for next week professionally?