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Work in Progress: Preparing an Interdisciplinary cohort of Postdoctoral Scholars for Convergent Quantum Education Research

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Background

This Work-in-Progress paper describes the professional development efforts planned for a cohort of three postdoctoral scholars who will engage in convergence research to advance equity and inclusion in the emerging field of quantum information science and engineering (QISE). The overall project is funded by an NSF Organizational Postdoctoral Research Fellowship. The fellows will be drawn from a diverse set of fields, including physics, engineering, STEM education, psychology, sociology, and cultural studies. Together, they will explore research questions that build an understanding of how quantum education and workforce development programs can be designed to create a diverse and inclusive quantum workforce. QISE is inherently multidisciplinary and is a new and rapidly growing area. Hence it provides a unique opportunity to build a workforce from the (near) beginning and to address issues of equity and inclusion at the education and workforce development stages before inequities arise in the workforce. Bringing together postdoctoral fellows from diverse fields and identities allows us to understand this challenge through several lenses and to conduct research that leverages expertise and techniques from education, sociology, and other fields. The fellowship program is designed to enhance fellows' research skills, build their capacity for convergence research, and support them with wrap-around services that will help them emerge as leaders in this field.

Professional Development Overview and Key Competencies

As the three postdoctoral fellows are expected to be recent PhDs with diverse academic backgrounds and will be tackling challenging research questions at the intersection of their areas of expertise, professional development will be a critical aspect of the fellows' experience. The professional development activities will aim to strengthen their learning, growth, and cultural competency (i.e., cultural awareness, sensitivity, humility, and responsiveness). While each fellow will start with a subset of the desired key competencies, our aim is that all fellows will achieve the following outcomes by the end of the program:

- Understand key concepts in QISE
- Possess strong mixed methods research skills
- Work effectively with a diverse research team to execute convergence research
- Possess strong communication skills to support presentations, papers, and grant proposals
- Develop an increased cultural awareness, sensitivity, humility, and responsiveness that allows them to connect research questions with actions that can break down barriers to social progress.
- Understand the research paper writing process, resulting in authorship

These competencies will be developed through research on existing projects, the development of the cohort's convergent research project, classes (as appropriate), an orientation program, bi-weekly group meetings, professional learning workshops, individual support and mentoring, and opportunities to engage with professional networks in and beyond the host institution. Formal professional development will be designed by a broad team (including both project leaders and

experts drawn from across the institution) with expertise in designing and leading professional development for faculty, graduate students, and K-12 teachers. Fellows will engage in professional development through a variety of mechanisms, described below.

Orientation Program: The fellowship will begin with an intensive two-week orientation program to prepare the fellows to get the most out of their two years in the cohort. The orientation will also provide a venue for building a cohesive group and setting group norms, which will be critical to making the cohort research project successful. The orientation program will include a two-hour morning session with structured activities, followed by a group lunch that can provide additional time for discussion in an unstructured setting. Orientation session topics include setting group norms, introducing ongoing STEM education research projects, brainstorming with research advisors to identify roles in ongoing projects, building an individual development plan and e-portfolio, and cohort project brainstorming. The project leadership team, along with additional experts in QISE and in STEM education, will lead the sessions.

Individual Development Plans and E-Portfolios: An Individual Development Plan (IDP) will be used to identify both the professional development needs and career objectives of the postdoctoral fellows. During the orientation, fellows will create an IDP using myIDP (myidp.sciencecareers.org) supplemented with an additional questionnaire relevant to STEM education researchers. In their IDP, fellows will define their next-steps and long-term career goals. They will be assigned a primary mentor from the leadership team who they will work with to identify the steps that they need to take to reach these goals, including skills that they need to develop and mentors who will help them along the way. The IDP will be coupled with an electronic portfolio (e-portfolio) that fellows start during the orientation in order to build a record of their development as a researcher, communicator, and transdisciplinary team member. Fellows will be asked to continuously update their portfolio and to write reflections on their progress including successes that they have had and barriers or challenges that they have faced each quarter. The reflection will be discussed with mentors and fed into their individual development plan so that the mentors can understand what is working well and what changes need to be made.

Regular Meetings: As part of their professional development, fellows will engage in regular meetings with several different mentors and collaborators. In recognition that at least weekly interaction with advisors contributes to fellow's success [1], each fellow will meet weekly with their primary research advisor. In addition, each fellow will be assigned a primary mentor from the leadership team and will meet with that mentor at least monthly to develop their individual project. Fellows will also engage in bi-weekly meetings of the cohort and the PI team to discuss the cohort project and how the fellows are progressing in their individual work. Bi-monthly, the research meetings will include attendees outside of the core team to provide a broader audience as the fellows present their work, add additional insight, and help build/extend the fellows' networks and social capital, and help them learn useful skills. Finally, we will hold monthly, 90-minute, professional learning workshops for the fellows and other post-doctoral and graduate education researchers at the institution. Topics include developing data-driven visuals, technical writing, writing for non-academic audiences, career trajectory planning, and writing research proposals. The workshops will be presented by project faculty or others recruited for their expertise. (Funds have been budgeted to support recruting experts from across and beyond the institution to lead these workshops.) They will be active sessions that will engage participants in learning new tools and techniques.

Mentoring: Success in the academy requires building and navigating relationships. It is through these relationships that the postdoctoral fellows will develop a community that can help them identify and navigate their career paths. Mentorship efforts will also include support and guidance as the fellows identify specific skills that will be needed to achieve their professional goals, overcome challenges encountered along their path, build collaborations that will sustain their work, and gain support from a community that will help propel them into their future careers. Fellows from historically minoritized and marginalized groups may encounter negative stereotypes and experiences along their path, making the role of their mentors that much more critical to their success. Mentors can't keep mentees from having these negative experiences, but they can help support them when these experiences impact their self-efficacy and sense of belonging [2-4]. For fellows in general, but for those from historically minoritized and marginalized groups in particular, mentorship needs to be more than "instructional" [5] and needs to help mentees navigate the academy, develop networks that will be critical to advance their work, and promote their work to others.

We will employ Chapman's Thrive Mosaic developmental framework [6], which was created to support the development and success of scholars from marginalized groups. It focuses on the development of sub-networks focused on scholar development, advocacy, and self-care. The goal of this framework is to mitigate external and internal factors that may serve as barriers to scholar success, thereby "actively forestalling systemic marginalization and obstructionist practices" [6, p. 600]. Chapman noted that graduate students and postdoctoral researchers particularly benefit from having *associates*, *connectors*, *mentors*, and *advocates* [6]. For our implementation, *associates* are the other fellows in the cohort, and they are tasked with holding each other accountable for meeting shorter-term deadlines and longer-term goals. *Connectors* help scholars connect to influential people in their research area. Project leaders and researchers will serve as connectors, bringing fellows into professional networks and connecting them to renowned researcher. Each fellow will be assigned a primary *Mentor* who will focus on the fellow's progress along their overall career trajectory using the IDP to map and track the fellows' goals and progress. *Advocates* will help facilitate the fellows' access to professional opportunities. For this project, the advocacy role belongs to everyone involved in the effort.

The Thrive Mosaic framework also engages team members in examining their own biases and assumptions, through critical reflection, to develop cultural competency. This will be folded into our work with the fellows across the mentoring relationships we will build. Part of setting group norms during the orientation will be introducing these roles which will be reinforced during the regular group meetings during the fellowship.

Mentors for the postdoctoral fellows will be drawn from within and outside the host institution and will represent a diversity of backgrounds and experiences. The 14 mentors from the host institution have backgrounds in physics (2), engineering and computer science (2), education spanning expertise in special education, physics and teacher identity, STEM for English learners, gender in education, and opportunities for historically underrepresented, international, and immigrant students in higher education (8), behavioral psychology (1), and business. They represent a diverse intersection of the university community and will support the fellows by providing a range of expertise and lived experience.

Research Skill Development

Building a career as a STEM education researcher requires the development of key research skills, including mixed method data analysis skills, the ability to define and investigate a research question, project management skills, and both written and oral communication skills.

"Activities that will actively engage fellows in ongoing and independent research projects that promote their development beyond their doctoral dissertation work and help establish them as self-directed scholars" is one of the key pieces of the NSF program supporting this work. Because we expect that existing research skills may differ significantly across the fellows, possessed by the fellows, we will personalize support for skill development. Tailored mentoring and the use of IDPs will allow for personalized professional and skill development. Joining an existing research project will target each fellow's research growth by selecting a project that makes use of skills the fellow wants to develop (e.g., interviewing and qualitative analysis). Fellows will be supported in taking courses in research and data analysis methods as needed.

The cohort research project will build the fellows' project planning and management and skills. It will teach them to work in a team and will make use of their data analysis skills. Ultimately, they will work on publications and contribute to the writing of at least one grant proposal. Topical knowledge development (QISE, broadening participation in STEM) will be developed through the research projects and discussions in the group meetings.

Fellows need to develop knowledge of topics as diverse as key quantum concepts, teacher professional development, K-12 STEM education, STEM higher education, experiential learning, and workforce development. In addition, they need to become deeply familiar with the literature on barriers in STEM education for underrepresented groups as seen through a variety of lenses. In the process of building diverse expertise, the fellows and the broader research team will develop a shared language to discuss their perspectives on the problem at hand. Building a shared language is a challenging but critical piece of developing a convergent research project.

Next steps: Evaluating the Effectiveness of Professional Development Efforts

We are still in the design stage of this project, but we are thinking forward toward assessment of this professional development effort. We will focus on the following questions to evaluate the impact of our postdoctoral professional development: How effectively are fellows supported in conducting convergent research? To what extent do fellows receive career guidance from faculty and other mentors, and how does this guidance help define their career goals? To what extent does the program launch fellows into positions that match their career goals? How confident do fellows feel in their readiness to navigate and succeed in an academic career? Our assessment of the impact of the professional development will be based on qualitative data, including notes created during project meetings and mentoring meetings, Likert-scale surveys at several key points during the fellowship period (e.g., before beginning, after orientation, etc.), reflections and entries in e-portfolios, and interviews with fellows, faculty, and other mentors. Through the data we collect, we aim to identify insights about different aspects of the fellowship experience and how fellows' professional development needs evolve during the fellowship period.

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