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STEM Education Research Incubator (SERI): Developing a More Holistic Mentoring Ecosystem

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At a regional private institution in the Midwest, undergraduate students can apply to participate in a research challenge (URC). The program is well supported and is often listed as a highlight of student experience. The process includes the student finding a professor and project of interest and then applying to work with the professor as a faculty mentor. Students complete community service and research hours then present their findings publicly, often in a showcase for URC students. However, it is largely faculty driven and a singular experience. This paper presents an emerging case study and answers the research questions 1) What affordances does a cohort model provide undergraduate STEM research students? 2)What influenced the choice to apply for a cohort experience? 3) What tasks and artifacts emerge from the cohort? Elements of Ecological Systems Theory are interrogated and expanded as well as current models for STEM mentoring, which largely do not include undergraduate student research or student-centered cohort models. Data is also reconceptualized using the Data Engagement framework as being made rather than found, assembled rather than collected and dynamic rather than complete or static. The author modified the overall experience to provide cohort mentoring and a student-centered holistic approach to the URC enterprise. Instead of students joining an ongoing faculty-led project, they apply to be a part of the STEM Education Research Incubator (SERI). Students are accepted and work collaboratively with other students and the author to form research questions and learn basics of the research process, expanding participation in multi-directional and multi-positional contexts, presenting their work in research venues. SERI shifts to a collaborative cohort mentoring model. A more holistic student-centric model keeps the relational direction not only moving from uni-lateral to multi-lateral, but also from uni-positional to multi-positional as members become part of an ecosystem of mentoring.

Keywords: Cohort mentoring, undergraduate STEM education research, data engagement, mentoring ecosystems

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Introduction

With the recent shift in priorities at the National Science Foundation, and reflection on the author's own mentoring relationships across multiple contexts, reconceptualizing mentoring for undergraduate STEM education students became more important and fostered curiosity about possibilities. Instead of broadening participation language and constructs in which underrepresented minorities and their identities are the focus and actively recruited to STEM endeavors (a commitment of the author) a conversation took place between the author and one of their mentors. What if these efforts of broadening participation are no longer a priority? What if efforts of broadening participation focusing on identities inadvertently "others" those the author and many others seek to include and support? This led to the reconstruction of the author's STEM education research trajectory to consider more holistic approaches as an overarching concept. Instead of seeking out and requiring students to choose identities, which can be difficult at times, excluding and making those that are seemingly being supported, feel different, what would a more holistic approach look like? In a recent personal conversation, an executive-level administrator working in broadening participation in STEM education and research stated, "What am I?" when we were collaborating on research projects (C. Hall, personal communication, April 24, 2025). What might it look like to promote cohort mentoring, with all identities students bring, and make them part of the process? These are portions of the reflections that author and a mentor explored, leading to a shift in the current approach to an undergraduate STEM education research challenge.

This shift includes inviting interested students of all backgrounds to apply using the current URC processes and including in the description brief statements of the cohort style of work. These include focusing on the community and input of the members, and de-centering the experiences and research of the faculty mentor. The faculty mentor would facilitate the students' processes and research interests, maximizing opportunities for student input. Playing with three overall constructs as a conceptual framework, and in the context of a case study, investigating a new way to mentor students in an undergraduate research challenge is offered. The lenses of systems, mentoring and data are used to form questions related to a cohort model that is not focused on individual identities of underrepresented minorities in STEM education research or centered on the faculty mentor, thus expanding the relational and positional contributions of the undergraduate research students in a more holistic manner.

Literature Review

Although mentoring literature is well established, there is less on cohort and holistic models in undergraduate STEM education research, where the faculty mentor is less centered than the student experiences and needs. Additionally, there is a vast amount of literature with identities of marginalized groups as the focus of interventions, recruitment and mentoring. Likewise, methodological literature abounds on both qualitative and quantitative approaches to research, but less on inclusion of types of data and how to reconceptualize the way data is obtained and analyzed. The literature that informs this study explores systems theory, Data Engagement and current mentoring models. These perspectives collectively highlight how mentoring functions across personal, institutional, cultural, and epistemological dimensions, but is not always student centered or holistic in approach.

Systems Theory

Bronfenbrenner's Systems Theory (1993) conceptualizes human development through five nested systems: microsystem, mesosystem, exosystem, macrosystem, and chronosystem. Each level offers insight into how mentoring could be shaped and delivered, and how students may develop in a mentoring environment. Current mentoring models can be aligned with each of these nested systems. At the microsystem level, Pedersen et al. (2024) emphasize that psychological similarity between mentors and mentees enhances developmental networks. Bradley et al. (2017) show that mesosystem interactions, such as multi-mentor models, support holistic student growth.

Exosystem factors like institutional policies, described by the National Academies (2019), shape mentoring access. Macrosystem values, as Robnett et al. (2018) note, affect how culturally responsive mentoring promotes inclusion. The chronosystem highlights how sustained mentoring (Estrada et al., 2018) fosters long-term engagement in STEM careers, which may be the goal of the research students. These applications to Systems Theory address pieces of productive mentoring, yet allow for more investigation into an integrated and holistic approach. It becomes problematic when identities are centered, which are fluid, and aligning identities between cohort members may be fluid as well. Creating new similarities, in the form of shared meaning would be possible in a cohort model. Attending to the newly created culture of the cohort would be inclusive of all that each member brings to the group. The nesting components of the theory is helpful in the current development of a cohort model.

Data Engagement

Ellingson and Sotirin (2020) introduce a critical materialist approach to data, reframing it as a product of relational, embodied, and contextual practices. This view, when applied to mentoring, positions undergraduate researchers as co-constructors of knowledge. Within this framework, mentors guide students not just in data collection but in reflective, ethical interpretation based on joy, compassion and pragmatism. Cohort members may develop a research perspective and identity through epistemic inclusion and co-analysis. In Data Engagement, research becomes a collaborative and affectively charged process, deepening student engagement, challenging accepted power structures and what is and is not included as data. In proposing a cohort, more holistic model, how data is conceptualize and seen, and what researchers include and actually do with data is intriguing and applicable when considering a different way to mentor undergraduate STEM education research students.

Mentoring Models in STEM Research

A variety of mentoring models have been identified, including near-peer mentoring, multi-mentor models, and communities of practice (Leonard et al., 2019; Lave & Wenger, 1991.)

These models highlight promoting a sense of belonging (Zaniewski & Reinholz, 2016), improve satisfaction of STEM experiences through diverse mentorship (Bradley et al., 2017), fostering positive STEM identities and persistence among underrepresented groups (Robnett et al., 2018) and must evolve into structured mentorship ecosystems supported by institutional policy (National Academies, 2019). These models have had success in their stated goals and with improving student experiences in facets of STEM endeavors. However, many of them are program specific, which requires students to identify a certain way, and are largely dependent on the faculty mentor's line of research. Communities of Practice and near-peer interactions offer insights into possible cohort development while allowing for various contributions and growth of the cohort members.

Mentoring can include undergraduates and is a multilayer process that is informed by ecological, epistemological and practical considerations. By integrating Bronfenbrenner's systems theory, Data Engagement methodologies, and current STEM mentoring structures, we see what has been done and what is needed. Although holistic interpretations, inclusion efforts and identity work have been mentioned, cohort applications within a systems approach while examining methodological expansion is understudied. In addition, with the shift in priorities of funding bodies and national administration, focusing on elements of identities does not align. However, this may provide an unexpected opportunity to reconceptualize mentoring and investigate aspects of holistic cohort mentoring, with a different kind of faculty mentor and student participation.

Methods

Case studies are described as explorations of a bounded system of a case involving multiple sources of information rich in context (Creswell, 1998; Yin, 2018). In this qualitative case study, five undergraduate STEM education research students were included. They are all 21 and over and are all junior status or above. The majors include mechanical engineering (2), psychology, organizational studies and cyber security/ computer science. They are all accepted into an Undergraduate Research Challenge (URC) in which they participate in 200 research hours and 40 hours of community service. Their identities include a range of socio-economic status, race, class and gender. In the spirit of becoming more holistic identities are shared in aggregate. Three students did not meet the requirements for being in the URC program in the SERI.

A variety of data sources were collected to analyze in pursuit of answering the research questions and exploring the SERI cohort. These sources are outlined in Table 1. Two formal application interviews were held with all potential cohort members and the faculty mentor. Four informal cohort meetings provided opportunities for guided and spontaneous dialogue. In addition, a student interest survey, given to all cohort members upon acceptance to the group, elicited specific information regarding members' expectations, needs and questions. Individual mentor meetings occurred on an as-needed basis. These were designed to offer personalized academic and research guidance, most often surrounding research topics and questions about the URC in general. Textual data such as meeting notes was collected including those from the faculty mentor and students if they chose to share them. Group Chat exchanges using Microsoft Teams included 108 interactions. These served as a record of ongoing communication among cohort members. Lastly, three student-created artifacts including a document for recording participation, time and questions, a student generated question/prompt with accompanying language for engaging with peer reviewed required readings, and individual research biographies that were interactive in nature were included. Data sources are summarized in Table 1. All data sources were analyzed for themes, by transcribing and collecting all forms of written and verbal data. Repetitive phrases, ideas, words and constructs were noted and annotations or codes generated. Individual codes were assigned to the data and organized according to placement in corresponding themes. Data that emerged was analyzed as part of the corpus of data and organized by the theme "artifacts."

Table 1
Overview of Data Sources

Data Source	Frequency	Participants	Notes
Application meeting	2	All applicants	Conducted prior to acceptance and to help clarify fit and expectations.
Informal cohort meetings	4	All cohort members	Discussions and peer support
Individual mentor meetings	As needed (3 cohort members)	Faculty mentor and individual students	Individualize support and dialogue
Group Chat message exchanges	108	All cohort members	Informal communication
Text messages	47	Individual cohort members	Questions and clarification
Artifacts (student generated)	3	Student-authored	Record keeping, reading guide, research biographies

Total 168

Results

The entirety of the data, excluding the final artifact generated by the students to complete the ongoing project was analyzed for overarching themes using qualitative methods (Creswell, 1998). Each piece of data was read and initially organized into the overarching headings of Faculty or Student. This originated at the first iteration of analysis by who had contributed. Upon further iterations of themes and subsequent coding and annotating the data, more nuances were identified resulting in themes of Faculty Traits, Collaboration Traits and Constructing Meaning. These move beyond who contributed into the descriptors and impact each piece of data signified. The artifacts were not included as text, but comments about the artifacts are included. More data and further themes and codes will be determined as the study progresses.

Faculty Traits (pertaining to all things faculty mentor)

Freedom

"…I do like the aspect that we are able to have freedoms to do what we want and explore our interests…"
"…we have to do things our way, with help… and are free…"
"In the traditional way, a faculty mentor can seem condescending toward students…kinda in a 'my way or the highway' type of thing
Relationships
"Dr. _____…accepted me…"
"…I know Dr. __ and enjoyed their class…"
"…I know they will be a great mentor for what I want to study…"
Emotion
"…I am happy…"
"…I have Loved their classes."

Collaboration Traits (pertaining to all things cohort participation)

Engagement

"I want to know how to work in a cohort and how to collect and analyze data…"
"…Wanting to collaborate…"
"It's kind of boring to only due annotations in a lab or only do the literature review."
"…maybe having a game night or grabbing lunch?"

Constructing Meaning (pertaining to shared experiences and emerging artifacts)

Tentative

"I am nervous about not having narrowed my research questions yet, but I am open to sharing and talking to others like I am talking to you (Faculty Mentor)"
"…my idea is to keep track of things like I did in ______ class. Should I share that…"

Artifacts

Generated Artifacts

These include a record keeping system, language and format for student generated questions on required readings and student research biographies.

"…I'm ok with us using my words for reading…"
"…I like that, and I will go first…"
"…people could add to the biography or profile if we have ideas…"

Discussion

A review of the research questions that are answered in this pilot case study include: 1) What affordances does a cohort model provide undergraduate STEM research students? 2) What influenced the choice to apply for a cohort experience? 3) What tasks and artifacts emerge from the cohort?

Each of themes and annotated code suggest that there are qualities in the experience students are interested in that differ from their choice to apply to a more linear and less holistic experience. Relationship with the faculty mentor (FM) was central to each case study member, yet one of the tenets of a more holistic, student-centered cohort would de-emphasize the FM. However, prior experiences with the FM, including taking classes was important and a determinant in choosing to apply. The interactions with the FM are described and how students were treated, including freedom to inquire, disagree and be respected as opposed to condescension. Awareness of and in some cases deconstructing power while aligning with intentional virtues or relational intentions is implied (Verma & Douglass, 2021; Verma, Puvirajah & Douglass, 2018). The desire to participate in more open inquiry, rather than closed inquiry was also mentioned and contrasted with participation in other projects.

The collaboration and constructing meaning themes included the annotated code of engagement. This represents a willingness and burgeoning awareness of the necessity of interaction with peers to deepen the skillset and experience of the research process, regardless of subject matter and including a variety of emotions and experiences. Engagement also referenced peer relationships including social engagement, too, as well as expressions of some trepidation and uncertainty. This hints at elements of authenticity, trust, and risk taking that enhance the peer experience and aligns with literature on benefits of communities of practice and near-peer relationships (Lave & Wenger, 1991; Leaonard et al., 2019). Co-constructing meaning relies on the engagement of all cohort members and is a deviation from the previous experiences in URC, or in the written descriptions of other URC projects. This can require practice and norming and allows for being in process and not merely a static, fixed identity with or orientation to research. With enough exploration and additional studies, an argument could be made that a complete paradigm shift needs to occur related to how students are mentored and by whom (Kuhn, 2012).

Regarding artifacts that emerged, according to the Data Engagement framework (Ellingson & Sotirin, 2021) data is made, assembled and becomes, based on ethical commitments of pragmatism, joy and compassion. The case study participants, made data in the form of their collective creation of a tool to organizing time and tasks of their research processes, sharing of research biographies, including their areas of interests and needs, with the invitation for other cohort members to engage in the biographical documents. This creation of artifacts relied on assets and Funds of Knowledge each member shared with the cohort (González, Moll & Amanti, 2006). Additionally, one member challenged the implicit power dynamic of FM with students with a dialogue they initiated. A disagreement with a required peer-reviewed research article was stated and interrogated. In the ensuing dialogue and information exchange, a high level of trust and dependence was demonstrated, combatting the often used stereotype that research is isolating or is as tidy as a "data set"- a static set of information without the underlying ethical frameworks or room for making, assembling and becoming data. This exchange brought about the artifacts of student generated questions for the cohort to engage with, and a prompt for interrogating research stated as "What gave you the ick when you read this article?"

Limitations

Limitations of the study include the timing, as it is the beginning of the course, and more data will be made as the course continues. In addition, as a case study, it is not designed to be replicable, but could offer possible insights into what affordances a cohort mentoring experience provides and the assets students bring. Artifacts and experiences can also be replicated with new groups of students, but each group would develop their own characteristics and experiences, most likely answering the research questions differently with subsequent groups. In addition, a limitation could be the location of the SERI within the larger URC. Despite the efforts to be more holistic and build upon cohort assets, during the large group sharing, if the experiences and outcomes are vastly different than the peers not in SERI, it could facilitate "othering" which would be the opposite of conceptualizing and creating holistic spaces.

Future research could be undertaken to develop a framework or matrix of holistic cohort mentoring for guiding undergraduate STEM education research. Since the current work is a case study, then adjusting and providing for more pilot studies with other groups would be needed to see if a framework that includes themes of faculty mentor, collaboration and constructing meaning emerges. Additionally, analyzing artifacts and tools cocreated would be appropriate as a guide to determine if in other groups they contributed to other cohorts' meaning making.

Operationalizing terms could be useful, both to situate this and further studies within the literature as well as distinguish the nature of the holistic cohort experience. In reflecting on the shift to a more holistic mentoring ecosystem, it is worth considering the need for the faculty mentor to release what has potentially been control and "gate keeping" to the research process. The researchr and faculty mentor identities are both embodied and in research literature, may be seen as problematic. Positioning the faculty mentor as a member, is a new way to consider the positionality of the researcher. Cohort mentoring requires a different way of being for the researcher as part of the group, too. Brokering access and relationship to information needed for the research enterprise requires relinquishing an agenda, or at times the plans made in order to center a student need or idea. Students may also consider what they are looking for in the URC. There have been many other students in the program, (which has been redesigned), who have had positive experiences. Continuing to identify what makes the cohort the cohort and what kinds of students choose to apply is worth pursuing. The literature provides insight into research programs, which have a more set agenda and tasks, as well as cohort models based on specific identities, subjects or goals, but there is a dearth of information on a more holistic model that aligns with frameworks used in this study.

Conclusion

For the five students currently accepted into the SERI cohort, reconceptualize mentoring as a cohort ecosystem is working. Faculty mentoring that is decentralized, yet relational which shared power and guidance is allowing for collaboration and co-constructing meaning. Cohort members are able to show up with all of their identities and work collaboratively to engage in the research process. Authentic production of artifacts and more open and guided inquiry appeals to these students and they are willing to commit to the group and growth, even as there is flexibility and surprise along the way. This is a reconceptualization of a mentoring ecosystem and allows for student assets to be centered as well as different avenues of legitimate participation.

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