

STEMentor: A Mentorship Typology for Supporting Effective Youth-Mentor Interactions in Rural Communities

Srinjita Bhaduri*, srinjita.bhaduri@colorado.edu

Quentin Biddy*, quentin.biddy@colorado.edu

*University of Colorado Boulder

Abstract

Rural youth need more opportunities to participate in enriching STEM experiences and career pathways compared to their peers in urban areas. This study explores local mentors' role in shaping these pathways and addressing challenges related to STEM mentoring for rural youth. Through a three-year STEM program incorporating programmable sensor and 3D printing technology curricula, we establish a typology of mentors and examine their interactions with middle school youth. Analyzing recorded youth-mentor interactions, we identified several practical mentoring approaches. Our findings highlight the crucial contribution of mentors in the rural STEM learning ecosystem, as they foster possibilities and open avenues for disadvantaged youth to envision bright futures and dream of exciting opportunities in STEM.

Objectives

Youth from underserved groups, such as English Language Learners (ELLs) and immigrant families, comprise a large percentage of the population in rural U.S. mountain communities. They experience lower confidence levels in their abilities, resulting in reduced participation and retention rates in STEM (Bhaduri et al., 2021; Beyer, 2014; Fox et al., 2009). This research examines the rural STEM learning landscape in a mid-Western U.S. mountain ski town and the role of local mentors in supporting and enabling this landscape. Mentoring contributes a robust solution, supporting rural youth with limited access to quality education and resources (Bhaduri et al., 2021; Bhaduri et al., 2023; Kuperminc, 2016).

Mentors are vital in offering academic guidance, and fostering a positive learning attitude, enabling youth to overcome obstacles and improve their academic performance (Kuperminc, 2016). They serve as positive role models, addressing rural youth's isolation and lack of personal development opportunities (Bhaduri et al., 2023). It opens doors to new experiences, perspectives, and career options beyond youths' local community, broadening their horizons and guiding them toward informed decisions about their future (Bayer et al., 2015; DuBois et al., 2002). Although researchers examined the significance of mentors in the lives of children, there still needs to be more research concerning the support mechanisms for youth-mentor interactions within rural communities. Attention should be given to exploring different interactions, such as virtual vs. in-person, near-peer mentors vs. guest speakers.

In this study, we explore different types of mentoring and present a mentorship typology developed from analyses of youth-mentor interactions during a three-year STEM program incorporating programmable sensor and 3D printing technology curricula. Our research addresses the following question: “What best practices in youth-mentor interactions create enriching learning experiences for rural youth, fostering their discovery of STEM career opportunities and pathways?”

Theoretical Framework

STEM researchers have actively developed programming and engagement opportunities for rural youth (Atkins, 2020). These opportunities allow youth to engage in STEM activities within their local

communities, significantly impacting their perception of future involvement in STEM fields (Bhaduri et al., 2023; Tan & Calabrese Barton, 2020). The STEM program we discuss here involves many youth who are immigrants or descendants of immigrants. These youth face challenges related to their race, gender, and socioeconomic status as they navigate their STEM learning journeys and forge unconventional paths through "path hacking" (Tan & Calabrese Barton, 2020, p.11). We build on this characterization of STEM learning pathways as the real and imagined geographies of learning that youth traverse. We study the interactions with STEM professionals acting as mentors, as it plays a significant role in shaping youths' understanding of STEM and its boundaries in rural mountain communities.

To address these constraints, we adopted an approach called backcasting (Quist et al., 2006; Robinson, 1988), which envisions alternative ideal futures that may diverge from current trends and expectations. It involves exploring existing and near-term technologies to move youth closer to these imagined futures (Quist et al., 2006). Instead of designing technology solutions based on hegemony, youth can envision how programmable sensor technology and 3D printing can address issues that matter to them and their lives. Integration of backcasting and mentorship can empower marginalized youth in STEM programs, allowing them to dream and shape a future where technology serves their needs and aspirations.

Methods

Research Context. Our research focuses on youth-mentor interactions within two technology and career-integrated curricula units implemented multiple times over three years in both in-school and out-of-school settings. These curricula focused on programmable sensor and 3D printing technologies, lasting 4-6 weeks, and were adapted from an open-source curriculum called Sensor Immeersion (Gendreau Chakarov et al., 2019) to include mentoring experiences and STEM career connections. The curricula align with the Next Generation Science Standards (NGSS) and use a storylining approach, where youth questions about local phenomena drive the lessons to promote coherence, relevance, and meaning (Biddy et al., 2021; Reiser et al., 2021; Shelton, 2015)

The integrated career connections involved exposing youth to STEM careers and providing them with STEM mentoring experiences. Mentors offered firsthand insights into their STEM careers and technology-related project design. Interactions with mentors varied from in-person to virtual meetings, including limited interactions with guest speakers joining classes virtually, in-depth engagement with local STEM professionals from the community, and field trips to local organizations where mentors worked.

Participants. Our study involved 1470 middle school youth participating in different implementations of the two units. Of the participants, 52.1% were Hispanic or Latino, 28% were eligible for free and reduced lunch, and 33.9% were ELLs. We recruited 57 mentors, all STEM professionals with diverse occupations, such as technicians, engineers, roboticists, research scientists, and park rangers. Some mentors were high school and college students with experience working with the technologies youth explored.

Data. Data included responses from youth surveys, youth interviews, ethnographic field notes, and video recordings of youth-mentor interaction during different implementations of the instructional units. Table 1 below describes various data sources collected and analyzed for this work.

<Insert Table 1 Here>

Data Analysis. We used the grounded theory approach (Corbin & Strauss, 1990) and interaction analysis (Jordan & Henderson, 1995) to iteratively analyze mentors' strategies in working with youth and their resulting experiences. We performed an in-depth, iterative analysis of interactions between mentors and youth, working towards developing a consensus on the effectiveness of different types of interaction (Jordan & Henderson, 1995). It led to characterizations of seven mentoring types as classified in the mentorship typology. We then used auxiliary data to identify best practices from our analysis of the mentoring approaches.

Results - Mentorship Typology

Analysis of data sources led to the development of a mentorship typology. In the following sections, we provide examples of each type of mentoring (see Figure 1), explain how mentor meetings are carried out, discuss best practices for interactions, and explore the advantages and challenges associated with these interactions.

<Insert Figure 1 Here>

1. Mentors Meeting with youth VIRTUALLY (Whole Group). Mentors virtually meet the entire class (15-20 youth) 2-3 times during the instructional unit. Mentors share their STEM work, provide feedback on selected youth project ideas, and discuss their STEM career paths. Meetings are scheduled based on mentor availability and class times. Facilitators set objectives for each session and provide mentor training. Advantages include exposure to diverse STEM professionals and access to mentor labs. Challenges involve managing large youth groups; not all youth can feel connected to mentors.

2. Mentors Meeting with youth VIRTUALLY (Small Group/Individual). Mentors meet virtually with 3-4 youth 2-3 times during the instructional unit. They learn about each other's interests and experiences, building trust. Mentors provide insights and answer questions about each youth's projects to help them progress. Engaging strategies like icebreakers, agendas, technology expectations, and visual aids are essential in virtual space. Advantages include direct mentor support for project suggestions and benefiting youth with broader interaction opportunities. Challenges arise due to a low youth-to-mentor ratio, leading to potential pressure for youth to communicate, disconnection from mentors, and difficulty sharing projects or asking questions.

3. Mentors Meeting with youth IN PERSON (In Classroom). Mentors meet the entire class (15-20 youth) in their classroom 2-3 times during the instructional unit. Mentors circulate among youth, fostering natural conversations and relationships. Teachers are crucial in organizing and guiding meetings, ensuring focused discussions aligned with the mentor's expertise. Meetings include small group and individual interactions and whole group sharing. Advantages are direct youth-mentor connections, higher in-person energy, and richer conversations with non-verbal cues. Challenges include more time and travel requirements for mentors.

4. Mentors Meeting with youth IN PERSON (In the Field). Youth and mentors interact either at the mentor's workplace or in a field setting. During these interactions, youth engage in hands-on skills relevant to the mentor's work or collaborate on data collection for projects. Facilitators and mentors should plan activities to ensure a successful lab/field experience, considering rotation, service work, and exposure to diverse skills and jobs. Field experiences allow youth to test their projects and experience

real-world applications of technology investigation. Advantages include an opportunity for youth to see the mentor's workplace and real-world settings, instruments, and co-workers, creating a memorable experience that engages multiple senses. Challenges involve coordinating location, youth, and transportation requires effort from both the mentor and the facilitator to ensure a meaningful experience.

5. *HYBRID/Mixed (Virtual and In-person)*. Mentors meet with 6-7 youth 2-3 times during the instructional unit, using virtual and in-person interactions. One mentor may be present in person, while another may be virtual. Small groups or individual youth may interact with virtual mentors, while in-person mentors move among youth as they work. Virtual mentors may need assistance to join small groups by moving their computers or calling youth in a central area. Advantages include opportunities for youth to get the best of both worlds (virtual and in-class) for various interactions. It provides flexibility for the mentor based on their schedule and enables face-to-face time for youth compared to remote only. Challenges involve coordination when one mentor is in the room and the other remote to ensure balanced interaction and engagement with youth.

6. *STEM Expert Guest Speaker (Virtual or in person)*. A STEM professional shares knowledge or expertise directly related to youth project work. Youth learn about the speaker's career path and have time for questions and answers. This type of interaction does not include follow-up sessions with youth about their projects. It is generally a one-time interaction and follows a speaker approach (Bhaduri et al, 2023). Guest experts can be helpful as youth are in the beginning stages of exploring their STEM projects or gathering criteria and constraints for their design. Advantages include various topics speakers share with youth regarding their STEM projects and career pathways. Guest speakers commit to a one-time sharing with youth. Challenges involve a limited one-time interaction and are less impactful or memorable than multiple interactions.

7. *Near Peer Youth Experts (virtual or in person)*. Youth meet older students with experiences directly related to their project. For middle school youth, this includes meeting with high school or college students to share stories about their STEM work, high school/college classes and experiences, and their career aspirations. Near-peer youth experts need to be trained ahead of time to work with youth, connect their work directly to youth project ideas, and identify richer ways to interact with younger peers. Advantages include a clear next step for youth in their STEM learning trajectory and an understanding of STEM pathways that can become available. Near-peer youth benefit from sharing their experience with younger youth and become better communicators. Challenges involve less engagement from near-peer youth who are often obligated to participate in outreach activities which can lead to less valuable youth-mentor interactions.

Discussion and Scholarly Significance

Our work explored seven youth-mentor interaction types, elaborated in the Mentorship Typology; researchers and educators can utilize this to develop STEM mentoring for rural youth. Building strong and lasting relationships between youth and mentors takes time, and multiple touchpoints and diverse interactions yield the highest benefits for youth. While ongoing mentorship relationships are valuable, even one-time meetings can offer significant exposure to opportunities and STEM career pathways for disadvantaged youth.

Mentors often volunteer their time, and it can be challenging to find willing participants. Therefore, being flexible and allowing mentors to engage for as long as they can provide a meaningful experience for youth is essential. Ensuring mentors share skills or knowledge directly relevant to youth's STEM projects can foster a stronger connection and support backcasting opportunities (Quist et al., 2006), facilitating focused learning experiences personally relevant to youth. Learning each other's interests and life experiences can create a conducive environment for meaningful engagement, helping mentors tailor their mentoring approach to match youths' interests. Follow-up emails and continued communication provides opportunities for ongoing support, guidance, and mentorship beyond scheduled interactions. Thus, creating successful mentorship experiences for youth involves thoughtful consideration of their needs, clear communication of expectations, and flexible adaptation to optimize mentor availability and expertise. Our work suggests that by incorporating these elements and fostering meaningful connections between mentors and youth, the impact of mentor interactions on youth development, envisioning future pathways, and STEM engagement, can be maximized.

References

- Atkins, K., Dougan, B. M., Dromgold-Sermen, M. S., Potter, H., Sathy, V., & Panter, A. T. (2020). "Looking at Myself in the Future": how mentoring shapes scientific identity for STEM students from underrepresented groups. *International Journal of STEM Education*, 7(1), 1-15.
- Bhaduri, S., Biddy, L. Q., Rummel, M., Bush, J. B., Jacobs, J., Recker, M., Ristvey, J. D., Gendreau Chakarov, A., & Sumner, T. (2021, July), Integrating Professional Mentorship with a 3D-Printing Curriculum to Help Rural Youth Forge STEM Career Connections Paper presented at 2021 *ASEE Virtual Annual Conference Content Access*, Virtual Conference. 10.18260/1-2--37363
- Bhaduri, S., Elliot, C. H. & Biddy, Q. (2023) Local Mentors' Role in Rural STEM Pathways: Precarities and Possibilities. Paper presented at 2023 *American Educational Research Association (AERA)*.
- Bayer, A. M., Grossman, J. B., & DuBois, D. L. (2015). Using Volunteer Mentors to Improve the Academic Outcomes of Underserved Students: The Role of Relationships. *Journal of Community Psychology*, 43(4), 408–429. <https://doi.org/10.1002/jcop.21699>
- Beyer, S. (2014). Why are women underrepresented in Computer Science? Gender differences in stereotypes, self-efficacy, values, and interests and predictors of future CS course-taking and grades. *Computer Science Education*, 24(2-3), 153-192.
- Biddy, Q., Chakarov, A. G., Bush, J., Elliott, C. H., Jacobs, J., Recker, M., ... & Penuel, W. (2021). A professional development model to integrate computational thinking into middle school science through codesigned storylines. *Contemporary issues in technology and teacher education*, 21(1), 53-96.
- Corbin, J. M., & Strauss, A. (1990). Grounded theory research: Procedures, canons, and evaluative criteria. *Qualitative sociology*, 13(1), 3-21.
- DuBois, D. L., Holloway, B. E., Valentine, J. C., & Cooper, H. (2002). Effectiveness of mentoring programs for youth: A meta-analytic review. *American Journal of Community Psychology*, 30(2), 157–197. <https://doi.org/10.1023/A:1014628810714>

Fox, M. F., Sonnert, G., & Nikiforova, I. (2009). Successful programs for undergraduate women in science and engineering: Adapting versus adopting the institutional environment. *Research in Higher Education*, 50(4), 333-353

Gendreau Chakarov, A., Recker, M., Jacobs, J., Van Horne, K., & Sumner, T. (2019, February). Designing a middle school science curriculum that integrates computational thinking and sensor technology. In *Proceedings of the 50th ACM Technical Symposium on Computer Science Education* (pp. 818-824).

Jordan, B., & Henderson, A. (1995). Interaction analysis: Foundations and practice. *The journal of the learning sciences*, 4(1), 39-103.

Kuperminc, G. P. (2016). National Mentoring Resource Center Model Review.

Quist, J., & Vergragt, P. (2006). Past and future of backcasting: The shift to stakeholder participation and a proposal for a methodological framework. *Futures*, 38(9), 1027-1045.

Reiser, B. J., Novak, M., McGill, T. A., & Penuel, W. R. (2021). Storyline units: An instructional model to support coherence from the students' perspective. *Journal of Science Teacher Education*, 32(7), 805-829.

Robinson, J. B. (1988). Unlearning and backcasting: rethinking some of the questions we ask about the future. *Technological forecasting and social change*, 33(4), 325-338.

Tan, E., & Barton, A. C. (2020). Hacking a path into and through STEM: Exploring how youth build connecting pathways between STEM-related landscapes. *Teachers College Record*, 122(2), 1-44.

Table 1. Data sources used in the analysis and development of the Mentorship Typology and their respective descriptions

Data Source	Description
Student Electronic Experience Ticket (SEET) Survey	Survey for youth to reflect on their experience of learning/using sensor technology or 3D printing, the relevance of the unit to their lives, and feedback on mentor interactions. It is composed of three Likert scale questions and three multiple-choice questions.
Youth Interview	Interviews elicited questions about youth perceptions of STEM careers and how participation in the technology curriculum affected their understanding of available STEM career pathways. Youth were interviewed at the end of the implementation, and the interviews lasted 15 minutes.
Video Recording	Video recordings captured rich audio and video data of youth-mentor interaction and implementation of the instructional units.
Field Notes	Field notes of mentor meetings captured critical moments of youth-mentor interaction and were used to guide the interaction analysis with the other data sources listed above.

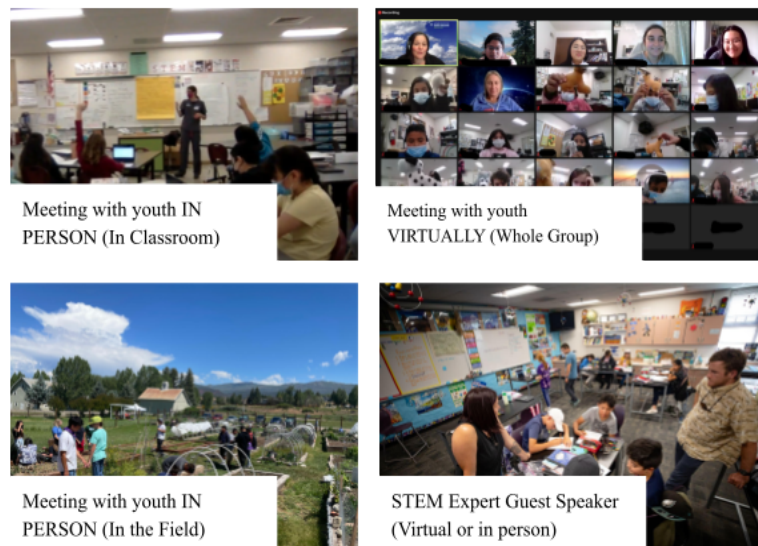


Figure 1. Examples of selected mentoring types as identified in the Mentorship Typology