Co-designing Opportunities for Rural Middle School Youth to Engage with STEM Careers and Career Pathways

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Abstract
Opportunities for rural middle school youth to engage in STEM experiences are lacking. We describe an approach to co-design STEM focused curricula (i.e. 3D printing and programmable sensor technology), integrated STEM career connection lessons and mentoring with local STEM professionals. Analysis of our STEM interest survey did not find significant differences based on student demographics or changes to the toolkit STEM career connections toolkit during the 2020-2021 school year. Qualitative analysis revealed that student understanding and knowledge of STEM as well as ability to describe STEM in their local context increased. While there is room for growth, it is clear that this model of co-design creates opportunities for rural youth to engage with STEM within their local communities.

Objectives and Purpose

Scientific inquiry and engineering increasingly necessitate knowledge of computation and computational tools to collect, analyze, and visualize data as well as develop models to explain phenomena (Foster, 2006). Likewise, more careers require individuals with experience and proficiency in STEM skills (National Science Board, 2020). Engaging youth in STEM experiences can spark interests and expose them to career pathways. Opportunities to engage in STEM experiences vary significantly according to geographic location, with rural youth having fewer opportunities (Saw & Agger, 2021).

Many rural middle school youth are unaware of what STEM is or what a STEM career entails (Bhaduri et al., 2021). This can be influenced by geographic contexts and careers readily visible to them through their families, friends and life experiences (Saw & Agger, 2021, Petrin et al., 2014). Exposure is one strategy to address this need. We investigate middle school youth engagement with local STEM careers and career pathways in a rural mountain community:

Research Question:

> How can co-design be used to develop opportunities for rural middle school youth to engage in STEM careers and career pathways in the context of a rural research practice partnership?

Perspectives and theoretical framework

Youth in rural communities have fewer opportunities to engage in STEM learning experiences in both in school and out-of-school-time (OST) contexts (Saw & Agger, 2021). A common issue faced is youth persistence and continued engagement (Leos-Urbel, 2015). We build on two strands of prior research to address this issue. The first highlights the importance of local knowledge and relevance for youth. Grounding science and engineering design challenges within local communities empower underserved youth to develop their narratives and understandings of their local communities (Taylor & Hall, 2013). Similarly, attending to local knowledge enables youth to see connections between emerging technologies and their local spaces. According to Bartko (2005), "youth who are committed to and highly active in an endeavor are more likely to continue in that endeavor, [and] see it as part of their identity". Anchoring learning in exploring phenomena and addressing challenges that are locally relevant enables youth to build interests from their everyday experiences, and explore how STEM contributes to their lives and community (Avery, 2013; Bell et al., 2013).

Next, we highlight the value of enabling underserved rural youth to construct personally relevant connections. Encouraging youth to relate STEM learning activities to their lives and values has positive impacts on interest and persistence in STEM (Harackiewicz et al., 2012). Interventions that help youth to make relevant connections between learning experiences and their lives are often most effective for low socioeconomic and minority youth (Harackiewicz et al., 2012; Hulleman et al., 2010). Groups traditionally underrepresented in STEM are present in mountain communities such as the one this paper studied. They include emergent English language learners and youth from immigrant communities who frequently experience lower levels of confidence in their abilities and have reduced participation and retention rates in STEM (Beyer, 2014; Buzzetto-More et al., 2010; Fox et al., 2009; Margolis & Fisher, 2003). We investigate the extent that co-designing with local partners enables youth to develop STEM applications within the context of their everyday lives, and connect with various STEM career pathways accessible in their communities.

This approach includes three components: 1) a community partnership working together to support youth engagement in STEM career pathways, 2) an in school and OST curriculum where youth use 3D printing and programmable sensor technologies to engage in science and engineering investigations, and 3) integrated career experiences that encourage youth to make connections with local STEM and computing mentors and occupations.

Bricker and Bell (2014) articulate STEM learning pathways as 'constellations of situated events" across places (social and material), actions (which have material consequence), and positions (individual in relation to community) which produce various interests and participations in STEM-related activities. Building on this framework, we articulate a STEM pathway as a set of experiences, developed to increase interest and participation in STEM, stitched together across formal and informal learning spaces for middle school youth. As part of this pathway, learning imbues developing perspectives on the future, both for the individual youth and for the community. By creating multiple pathways to STEM-related interests, we center STEM learning as an interrelated process developed from a constellation of situated events where youth encounter different community connections to STEM and careers, in afterschool programming, at summer camps, and in their middle school classrooms. Designing for and exploring this constellation, we explore how it frames access to different visions of futures for participating youth.

Methods, techniques, and modes of inquiry

We are working with partners in a rural mountain community focused on "niche" reform efforts to address challenges rural youth encounter regarding STEM learning. These partners include school staff (i.e. career/college coordinator and two middle school STEM teachers) and local OST providers. We build on Frumin's (2019) framework to examine how "co-design" can serve as an effective internal nurturing process for aligning partnership efforts. Co-design is a highly-facilitated, team-based process in which project stakeholders and researchers work together in defined roles to design and iteratively refine an educational intervention, to collect information on impacted educational practices and their context, and engage in collaborative efforts to promote common understanding between actors (Penuel et al., 2007; Roschelle et al., 2006). In formal education, co-design involving researchers and educators can produce high-quality STEM curricula and build district and teacher capacity to implement innovative learning experiences (Penuel et al., 2007, Severance et al., 2016, Chakorov et al., 2019a, Chakorov et al., 2019b, Biddy et al., 2020). Co-design activities took place over video conference meetings during the 2020-2021 school year and focused on what the future youth STEM learning experience would encompass (Hennessy Elliott et al., 2021). These co-designed curricula are currently being implemented in a summer STEM program in the same community.

Through this year-long co-design process (see Figure 1) various STEM learning experiences were stitched together to offer multiple opportunities for youth to explore STEM. This included two STEM centered curricula, one focusing on designing and 3D printing prosthetics for injured animals(Bhaduri et al., 2021) and another focused on using the Data Sensor Hub (DaSH) (Gendreau Chakarov et al., under review, Gendreau Chakarov et al et al. forthcoming, Biddy et al., 2020), where students design and program sensor systems to explore their world and create solutions for local STEM challenges. Second, a set of Career Connection lessons where students made connections between STEM curricula investigations and careers in their local community. Third, local STEM mentors met with students multiple times to provide feedback on student projects and real life connections for students to see relationships to local STEM careers.

Figure 1. STEM Career Connection Toolkit co-design and implementation during the 2020-2021 school year.

Data Sources

To study the impact of the co-design process, we collected semi-structured student interviews and student STEM career interest surveys. The interviews elicited questions about students' perceptions of STEM careers and how participation in the curriculum affected their understanding of available STEM career pathways. Interviews were conducted twice, at the beginning and end of the curriculum, lasting approximately 10 minutes, and n=81 students with informed consent participated in them during the 2020-2021 school year.

All participating students completed a STEM career interest survey before and after implementation of the unit. The survey was taken verbatim from Kier et al. (2013) with eight additional negatively worded questions to check for response consistency. While a pre/post analysis was underpowered and lacking a counterfactual to evaluate causation, we did review differences between students who took part in the mentoring program and those who did not take part in the mentoring program to provide internal feedback on what elements students were more or less likely to be taking up. Surveys also collected demographic information to look at if the program appears to be taken up similarly based on self-reported gender, ethnicity and language spoken at home. The survey was available in Spanish and responses were translated to English. The negatively worded survey questions were used to uncover inconsistencies (i.e. both liking and not liking science class) in students' responses and were excluded from analysis (276 responses dropped). We also removed 22 instances when the teacher had them take the survey at the wrong time (some students were given a survey mid-quarter instead of or in addition to a pre/post survey). After cleaning we had 259 matched student responses, of those 117 were in Q2, 109 were in Q3 and 33 were in Q4 (several post surveys were missing in Q4).

Data Analysis

We used an open coding approach to analyze the qualitative data (Strauss & Corbin, 1990), i.e., interviews, to determine emergent common themes about the effect of the unit on students' perception of STEM and STEM-related careers.

For the quantitative data, only matched responses to both the pre and post survey were analyzed using a repeated measures analysis on Stata (version 14.2) to analyze if pre-post differences in the survey responses varied based on quarter or teacher to illuminate if the program was taken up similarly based on different teacher or different elements of the toolkit that were implemented. Responses to likert responses were collapsed to remove gender bias from questions with the word "strongly" so each question only had agreement (value of 1), disagreement (value of -1) or a neutral response (value of 0). (Bush et al., 2020).

Two factors within the STEM career interest survey were identified based on the research question. First, questions about how students viewed STEM careers were combined into one outcome for analysis. Second, motivational questions were identified and combined into another outcome. These two outcomes were used as the dependent variables for the repeated measures ANOVA and Ordinal Logistic Regression models.

Results and Conclusions

Three themes emerged from student interviews. First, when asked in the pre-interview what is a STEM job or if they knew of STEM jobs students primarily talked about parents' jobs as being a STEM job regardless of career type. Second, related to the first theme, in Q2 (trial mentoring experience), in Q3 (career connections lessons), and in Q4 (all the components of the Career Connections Toolkit) students were better able to articulate and describe what a STEM job entails, how it differs from jobs only using STEM, and skills/schooling needed for a STEM career. Third, students made clear connections to STEM in their community, in Q2 connecting 3D printing prosthetics to sports medicine and veterinary jobs (integrated mentoring connection), in Q3 and Q4 identifying sensors in the real world and talking about how they work.

For the statistical analysis, pre-post differences were statistically insignificant for career ($F(1, 324)= 0.46$ $p=0.50$) and motivational constructs ($F(1, 324)=2.31$ $p=0.13$). The differences for career outcomes did not appear to vary based on quarter ($F(2,324)=0.33$ $p=0.72$) or teacher ($F(1,288)=0.01$ $p=0.94$). Likewise, these outcomes for motivation do not appear to vary based on quarter ($F(2,324)=0.16$ $p=0.85$) or teacher ($F(1,288)=0.32$ $p=0.57$). For all quarters there were no differences based on demographics pointing to equal uptake of STEM opportunities with no discriminatory effect.

Qualitative analysis appears to show that although student STEM interest did not significantly increase, their understanding and knowledge of STEM and their ability to describe STEM, especially in their local context, increased. Through the process of co-design with local stakeholders the partnership was able to stitch together various learning experiences (i.e. career connection lessons, STEM mentoring, and STEM focused curricula) to create opportunities for students to explore local STEM Careers and career pathways. Co-design could be one strategy for creating opportunities for rural youth to engage with STEM in ways that are specific to their communities.

Significance

This paper describes the use of co-design to develop opportunities for youth in rural communities to engage with STEM. These findings outline contributions to youth STEM engagement and awareness of STEM career pathways and opportunities and highlight the power of co-design with multiple partners in helping to develop local capacity and develop research practice partnership relationships.

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Figures:

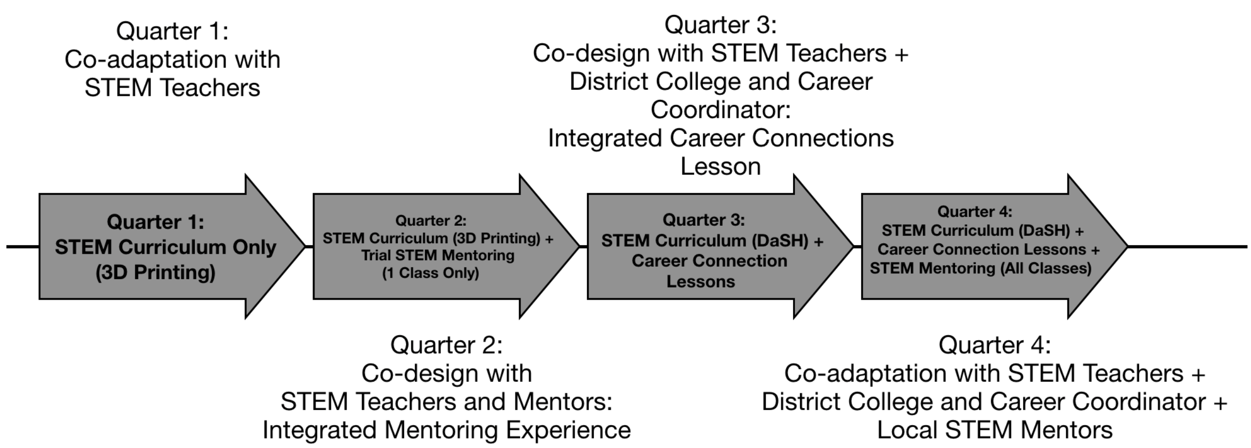

Figure 1. STEM Career Connection Toolkit co-design and implementation during the 2020-2021 school year.