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Instructional Strategies of Out-of-School Time Engineering Educators (NSF AISL)

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Introduction

In this National Science Foundation Advancing Informal Science Learning (NSF AISL)-funded research study, we are investigating ways to support informal educators in leading high-quality engineering activities in out-of-school time (OST) contexts. This four-year study focuses on understanding changes in OST educators' instructional strategies during participation in a community of practice-style professional development experience and subsequent teaching of OST engineering programs for rural elementary-aged youth. While the broader project includes identifying specific types of instructional strategies used by OST educators, such as identifying the ways in which educators talk with youth during engineering activities, and how youth respond to different types of talk, for the purpose of this poster we will be focusing on sharing our emergent Year 1 findings around one of our research questions: In what ways do informal educators' instructional strategies shift with the co-creation of, and participation in, professional development and a community of practice focused on engineering?

Background and Context

Out-of-school time educators have limited professional development opportunities, particularly around engineering, despite the discipline's popularity in informal learning contexts (e.g., afterschool programs, library workshops, or camps) [1]-[3]. Often, in efforts to meet the rapidly increasing demand for engineering or STEM-focused programs in out-of-school time, OST educators reasonably turn to free or easily-sourced curriculum. However, many of these activities are competition-based and narrowly constrained in terms of materials and time, which is contrary to what we know engineering learning should be: focused on solving open-ended, real-world problems that are relevant to learners and providing opportunities for learners to explore materials and iterate on solutions [4]. As engineering educators and providers of professional learning, we want OST educators to be able to identify, develop or adapt, and facilitate authentic engineering activities that achieve their goals for youths' learning.

In order to support OST educators to develop their understanding of engineering as a discipline and to build best practices for choosing and facilitating engineering activities with youth in OST settings, the research team co-developed and engaged in a community of practice (CoP). Communities of practice, more common in formal education, are typically composed of groups of professionals meeting together regularly to discuss, work on, and reflect on shared goals [5]-[7]. Year 1 of this four-year study included six experienced OST STEM educators who were all employed by the same university-based OST program, but were leading engineering programs at widely dispersed sites in rural areas. In the CoP, researchers and educators co-developed a series of six engineering activities that were subsequently taught by these educators either in afterschool programs, as part of existing camps, or as stand-alone mini-camps, to rural youth ages 8-12 years.

In the community of practice meetings, researchers and OST educators discussed engineering pedagogical practices, considered goals of teaching engineering to youth, and co-developed the engineering curriculum. While the broader goal of this study is to specifically understand educators' pedagogical talk moves – the verbal questions and statements educators say to youth working independently or in small groups during engineering activities [8] – in this first year of the study, we did not explicitly introduce or emphasize talk moves as an instructional strategy. In the first phase of this study, we focused on capturing and characterizing experienced STEM educators' existing instructional strategies and talk moves in OST engineering through recordings of the bi-monthly Community of Practice meetings, pre- and post- individual educator interviews, teaching observations, and group reflections on engineering enactments.

Instructional strategies, such as the intentional use of talk moves, are methods or techniques that educators utilize to interact with youth, with the intent of supporting youth learning about a particular topic or skill [9], [10]. General examples of instructional strategies include: experiential learning, design-based learning, instructional materials and resource choices, high-quality questions, and productive grouping of youth [10]. Talk moves are a specific example, relevant to the broader study here, of one instructional strategy that educators can use to elicit learners' engineering reasoning and sensemaking, encourage explorative learning, and support productive participation in engineering design [8], [11] [4], [5]. By using strategies shown to be effective, educators are more confident that the desired learning objectives will be achieved [12]. In this first year of the study, the primary goal was not to change how these experienced OST STEM Educators were teaching, but rather to observe, document, and begin to understand their choices around instructional strategies.

Community of Practice Overview

In Year 1, we had eight CoP meetings, occurring approximately every two weeks between March and June. Due to a compressed timeline, the CoP meetings overlapped with their facilitation of the engineering activities and were, as a result, intended to be responsive to the emergent needs of the OST Educators as they were preparing for and teaching the engineering activities. The research team intentionally interspersed professional development activities throughout the CoPs that were designed to elicit discussions about potential instructional strategies and goals, such as video observations, brainstorming, resource-sharing, and reflections on enacted engineering activities.

Year 1 Community of Practice Participants

OST Educators: The six OST Educators who participated in Year 1 had between 3-25 years of experience teaching engineering or STEM activities, in addition to other disciplinary topics. They each had a minimum of a BS degree, with some also having MS degrees in one or more of the following fields: Family Consumer Science, Agricultural Education and Leadership, Fashion Design, Curriculum and Instruction, and Biological Systems Engineering. Three of the six Educators had taken coursework related to teaching youth specifically, while only one Educator had formal education in engineering (BS and MS in Biological Systems Engineering). All Educators in the same university-based youth-serving organization who had prior experience leading STEM activities in OST settings were invited to participate in the research. Participating Educators received a $1000/year honorarium for full participation, in addition to the professional development opportunities.

Research Team: The research team consists of five university-based individuals, all of whom have prior experience teaching youth, in a mix of formal and OST settings. Two of the research team members are employed by the same university-based youth-serving organization as the OST Educators. All members of the research team are engineering education researchers and have experience developing and providing professional development for OST educators.

Analytical Methods

In order to begin understanding and characterizing the OST Educators' instructional strategies, we focused on analyzing the recordings of the Communities of Practice, as well as triangulating with field notes of discussions and activities that took place at an end-of-the-year in-person gathering of all the Educators and research team members. CoP meetings, which took place virtually via Zoom, were recorded and auto-transcribed. We reduced the data corpus of CoP meetings to content log summaries consisting of 5-minute segments. Each segment was tagged for speakers and provisional codes for topic of conversation.

We inductively coded the content log segments to identify emergent instructional strategies, drawing primarily on in vivo coding strategies [13]. Instructional strategies that originated from members of the research team were not coded. For the purposes of this analysis, we share aggregate findings of proposed instructional strategies across the community of practice meetings, rather than highlighting themes or shifts in individual educators. We then used thematic analysis to organize the instructional strategies and compare them across the temporal space.

Findings

In Year 1, we found that the most common instructional strategies discussed centered on the following themes: Pre-instructional planning and preparation for successful implementation of engineering activities (Pre-instructional planning), framing of the engineering challenges for youth (Framing), introducing or supporting engineering norms (Engineering Norms), connecting to real-world context (Real-World), and mid-design supportive talk moves (Talk Moves). While we were not able to discern a pattern or distinct shift in instructional strategies across the Year 1 CoP meetings, that is not unexpected given the compressed timeline across just four months. All names shared below are pseudonyms.

Pre-Instructional Planning: This group of instructional strategies was the most common, covering a variety of pre-instructional planning that the OST Educators recommended, noticed, or reflected would have been helpful. Instructional strategies that fell into this category included: constraints on the provided materials, scaffolding early engineering activities for success, constraints on options for possible solutions (while still offering multiple possible solutions), preparing materials ahead of the engineering activity, and organizing program time structure to allow youth time to think and share with others.

Framing: OST Educators talked about organizing the engineering activities around a central theme to encourage participation, centering particular engineering design activities around empathy, framing engineering as being a problem that needs a solution, and connecting to possible careers. For example, in CoP 5, OST Educator Barbara suggested that by organizing the engineering activities around a central theme, youth might feel more engaged.

Engineering Norms: OST Educators were very enthusiastic about supporting youth development of engineering skills and norms, specifically identifying: following the Engineering Design Process, progressively building engineering skills, supporting youth to work in teams during engineering activities, conflict resolution during engineering design, and engaging in client-centered design. In CoP 7, OST Educator Oliver, who had a background in engineering, described having youth engage in an activity that is common practice in engineering: client-centered design. Oliver told the Educators how he had directed youth to interview each other during the third engineering activity, prior to designing and building a desk organizer based on the needs and wants of their interviewee. He thereby introduced an instructional strategy to support client-centered design that was not a part of the original activity plans, but is a common practice in engineering.

Talk Moves: While OST Educators did not identify specific utterances as instructional strategies during the CoPs, as the research team had not yet introduced this construct, they did identify multiple instances where they would have verbally intervened while youth were mid-design, in order to support youth in moving forward with their design. These suggestions for instructional strategies included: Educators providing guidance while still offering youth autonomy in design choices, providing conceptual guidance, design guidance in the form of anticipating the failure of a design, time prioritization, and checking for understanding.

Real-World: The OST Educators regularly referenced the need for engineering activities to be connected, relevant to, or situated in real-world contexts. The Educators repeatedly pointed out that youth are more engaged and enthusiastic about engineering when they feel they are solving real or meaningful-to-them problems.

Other: There were several instructional strategies suggested or noticed by the OST Educators that, while less common than those listed above, are worth highlighting. These include the multiple recommendations around Educator positionality; specifically, that Educators should consider positioning themselves as co-learners or co-explorers rather than as experts in the engineering challenge. Another notable instructional strategy suggested was the implementation of end-of-session discussions to reinforce important concepts and skills from that engineering challenge.

Discussion and Conclusion

These preliminary findings are illuminating in identifying what types of instructional strategies these OST Educators suggested, noticed, or reflected on over the course of the initial, non-intervention year of the project. There were no clear patterns of change, which was as expected, but there were clear themes. The most numerous and frequent instructional strategies surfaced during the CoP meetings were centered around Pre-Instructional Planning; the work that Educators do in advance of an engineering lesson to ensure that it will go as smoothly and successfully as possible. While these instructional strategies often focus on the logistical aspects of teaching, such as what and how many materials are needed, these Educators brought up topics that were distinctly tied to engineering, such as whether or not constraining materials would limit possible solutions. We would not necessarily expect to see this level of insight with Educators who did not have prior experience teaching engineering. Conversely, we did not see evidence that this group of Educators was attending to all aspects of engineering design. For instance, we saw no Educator-suggested instructional strategies discussed regarding opportunities for youth to iterate on their designs ― a practice central to authentic engineering [4].

Going forward, we will engage in a two-pronged analysis to 1) triangulate these emergent findings around instructional strategies with OST Educators' stated goals in Year 1 pre- and post-individual interviews and in recorded engineering activities facilitation, and 2) analyze Year 2 Community of Practice meetings (currently in progress) for newly emergent instructional strategies. In Year 2 of this study, we are working with an expanded group of OST Educators, with whom we are deliberately engaging in developing and utilizing engineering talk moves, among other instructional strategies. We will also begin examining the possible effect of changes in instructional strategies on youth participation in engineering during these programs.

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