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Universal Design for Learning (UDL)- Strategies for Engaging Rural Youth Co-Researchers with Informal STEM Learning

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Universal Design for Learning: Strategies for Engaging Rural Youth as Co-Researchers

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Universal Design for Learning (UDL):

Strategies for Engaging Rural Youth as Co-Researchers in STEM

Abstract

This article describes methods and findings from a study focused on youth living in rural communities in northern New Hampshire who struggle with accessing STEM learning opportunities for reasons including economic underinvestment and geographical isolation. These challenges also negatively impact researchers hoping to learn how rural youth benefit from informal STEM learning experiences, which contribute to low-project participation and retention rates. As in other amenity-rich rural areas, the communities in this study are promoting outdoor recreation as a vehicle for economic development. We wanted to understand if outdoor recreation activities tied to economic growth initiatives — activities which youth have ready access to — show promise as a context for informal STEM learning. This article describes the unique research methodologies used in the study, including a mobile application designed around the Universal Design for Learning (UDL) framework. It also highlights the UDL strategies used to employ youth as co-researchers. While multiple factors contributed to the 96% retention rate in this project, the use of the UDL-based mobile app was significant, novel, and holds promise as a future strategy for increasing rural youths' engagement in STEM career and identity development activities.

Universal Design for Learning (UDL):

Strategies for Engaging Rural Youth as Co-Researchers in STEM

"I feel accomplished because I feel like my visions and overall look at life have improved since starting this project. I am more motivated, and I am thinking more about careers in STEM and outdoor recreation. This makes me wonder what my future will look like, and if it will look different now that I've done this project." — 10th grade co-researcher

Despite the fact that one in five U.S. students attend rural schools (Drescher et al., 2022), rural learners are underrepresented in STEM careers (O'Neal & Perkins, 2021). Contributing reasons include the challenges rural youth face in accessing STEM such as chronic underinvestment, geographical isolation, limited transportation networks, and periods of economic downturn and outmigration (Hamilton et al., 2008; Lavalley, 2018). To address this underrepresentation, researchers need to find relevant, authentic, and valuable contexts for rural youth to build their STEM identities.

Anchoring STEM learning in familiar environments increases learning and achievement (Goodrid, 2018; Hughes, 2012). In rural communities, youth rely on the outdoors for recreation to a greater degree than their urban and suburban peers (Seaman & McLaughlin, 2014), it is a core feature of rural identity, and it indelibly influences youths' future residential choices (McLaughlin et al., 2014; Ulrich-Schad, 2013). The outdoors therefore figures prominently in youths' "rural lifeworld" (Yahn & Ricket, 2023) as an important leisure context and a resource for educational and career identity.

For this project, we sought to leverage youths' participation patterns in outdoor recreation to promote engagement in informal STEM learning [video link to be inserted after manuscript is unblinded]. Based on prior research in the focal region and in other related studies (e.g., Civil, 2016; Lave, 1988; and Hill et al., 2018), we believed rural youth already *have* lived STEM experiences in the form of recreational activities, hobbies, craft work, or everyday activities, but these experiences were going unclaimed and unaccounted for despite their clear connection to science, technology, engineering, or math. Devaluing this "tacit STEM knowledge" — knowledge that comes from personal experiences but is hard to write down or articulate — impacts rural youths' STEM identity development (Fraser, et al., 2021). Through this study, we sought to work with youth to identify how STEM connects to their interests, supports the development of a "broader view of where STEM might be" (Allen et al., 2020), and positions their lived experiences (Avery & Hains, 2017) and place-based assets (De Mars et al., 2022) as strengths to promote STEM career thinking and STEM identity formation (Turner, 2023).

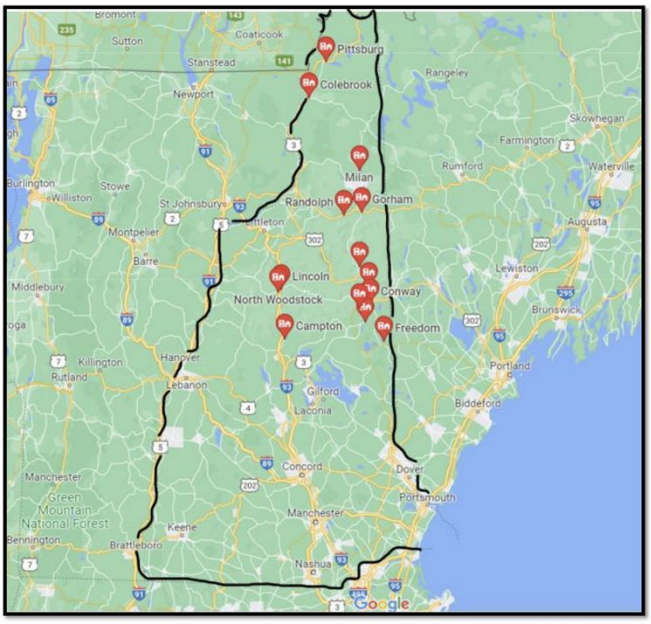
To test the feasibility of this concept, we needed to answer two fundamental questions: (1) How did youth participants see "STEM" in outdoor recreation? (2) How can youth be best engaged in capturing and expressing these insights? To answer these questions, we engaged youth as primary data collectors, considering them as co-researchers throughout the project. Therefore, retention in the 12-month project was critical. Working closely with project advisors our team identified common barriers that impact research outcomes with youth in rural communities, including a lack of time, transportation, and perceived value and trust with researchers, all of which inhibits the collection of robust data. We then proactively used

Universal Design for Learning (UDL) — an evidence-based framework for designing instructional practices and educational tools and materials that give all individuals equal access to and support for learning opportunities (Public Law 110-315, Sec. 103 (24)) — to structure collaboration with youth and increase the youth co-researchers' engagement in the project.

Project Design

We defined the eligible co-researchers to be northern N.H. youth in grades 7-11 from rural and small town communities in northern New Hampshire. The map in Figure 1 pinpoints the participants' communities of origin.

Figure 1
Map of Participants' Home Communities in Northern New Hampshire



We solicited youth involvement by using a two-step criterion sampling strategy with the help of key community adults who administered an initial sampling survey to inquire about activity preferences, such as how youth spend free time outdoors, outdoor interests, environmental concerns, barriers to outdoor participation (The Nature Conservancy, 2011), STEM supports (Christensen & Knezek, 2017), and disadvantage factors such as socio-economic

status, parents' education, racial identity, and "special populations" measures (Association for Career and Technical Education [ACTE], 2023). More than 200 youth completed the survey and 54 participants met the criteria for selection as co-researchers.

Youth were placed in cohort groups with a key community adult based on their community of origin. All 54 youth attended the in-person kick-off event in January 2023, marking the start of the project. Youth received training on how to participate in the study, including information about goals, expectations, and benefits of working as a co-researcher. This involved learning how to use the field data collection tool, ORfolio, an early stage, web-based app originally funded by the National Science Foundation (see Figure 2).

Figure 2
Youth Participant Being Trained as a Co-Researcher at Kick-off Event

At the training, youth practiced how to collect data using ORfolio in the field including strategies for taking high quality images and talking about the project with their peers and relatives. To ensure youth understood how to use ORfolio for capturing STEM insights, they participated in a mock activity involving a professional canine search-and-rescue expert. They used cartography, knowledge of animal biology, and GPS-coordinate mapping to find a

confederate who pretended to be missing. After taking part in the "search," youth uploaded field notes, photographs of the activity, and reflections on where and how they saw STEM being used. Youth reported that this training was instrumental in their participation and engagement as co-researchers in the project. As one participant commented upon reflecting on the project end:

> *"...I'll use the skills that I learned here and participating in this study to really be conscious of how I photograph nature around me and how I really see STEM in the outdoors in general. The technology in any outdoor activity, like skiing, snowshoeing, horseback riding, it's all a huge part of STEM. With nature all around you, you get to see so many more animals and be connected with the environment and I will always keep that on my mind for the rest of my life."* —9th-grade co-researcher

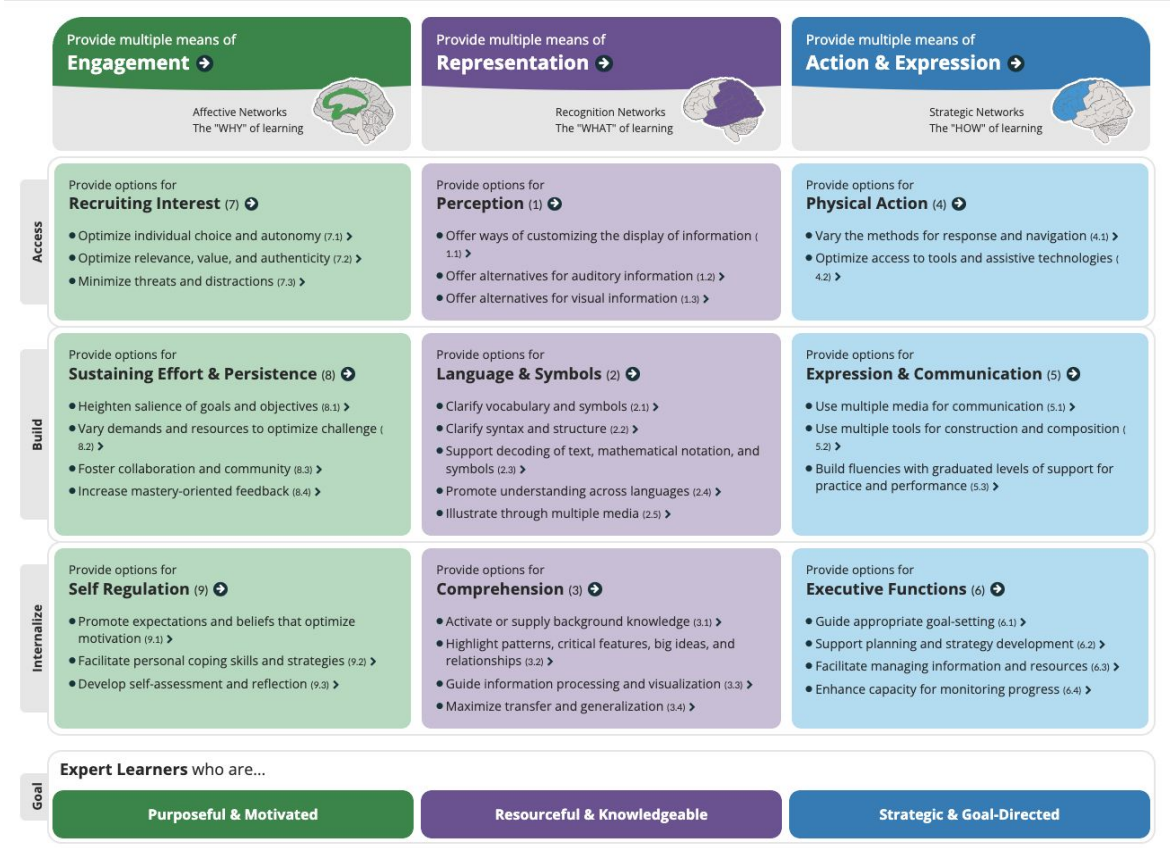
Throughout the remainder of the project, youth were asked to fulfill their co-researcher role by completing one ORfolio challenge or researcher-created prompt per month, attend nine monthly virtual small-group check-in meetings, and attend a final in-person wrap-up meeting in October 2023. At the wrap-up meeting, youth completed a retrospective post survey, answered additional reflection questions, and took part in personal reflection and analysis of data collected by themselves and their peers. To validate their role as co-researchers, youth earned $25 for each completed challenge with the opportunity to complete 14 challenges to reach a possible total of $350.

Using UDL to Facilitate Engagement

Echoing the concept of universal design in architecture, which aims to make spaces and information more accessible to individuals with disabilities (Mace et al., 1985), UDL expands

learning opportunities for the widest range of learners. UDL offers concrete suggestions for designing learning environments and learning experiences that are flexible, customizable, and accessible (CAST, 2018; Meyer et al., 2014; Rose & Meyer, 2002). The evidence base for UDL exists across grade levels, domains, and settings. UDL improved goal-setting, achievement, and motivation for science when a universally designed technology-based science notebook platform is included in inquiry science courses (Daley et al., 2014; Rappolt-Schlichtmann et al., 2013). UDL is effective in promoting positive and engaging learning experiences, reducing stress, and increasing learning satisfaction for learners at the secondary and postsecondary levels (Rappolt-Schlichtmann & Daley, 2013; Davies et al., 2012; Hall et al., 2015; He, 2014; Kumar & Wideman, 2014). UDL guidelines can be seen in Figure 3.

Figure 3
UDL Guidelines

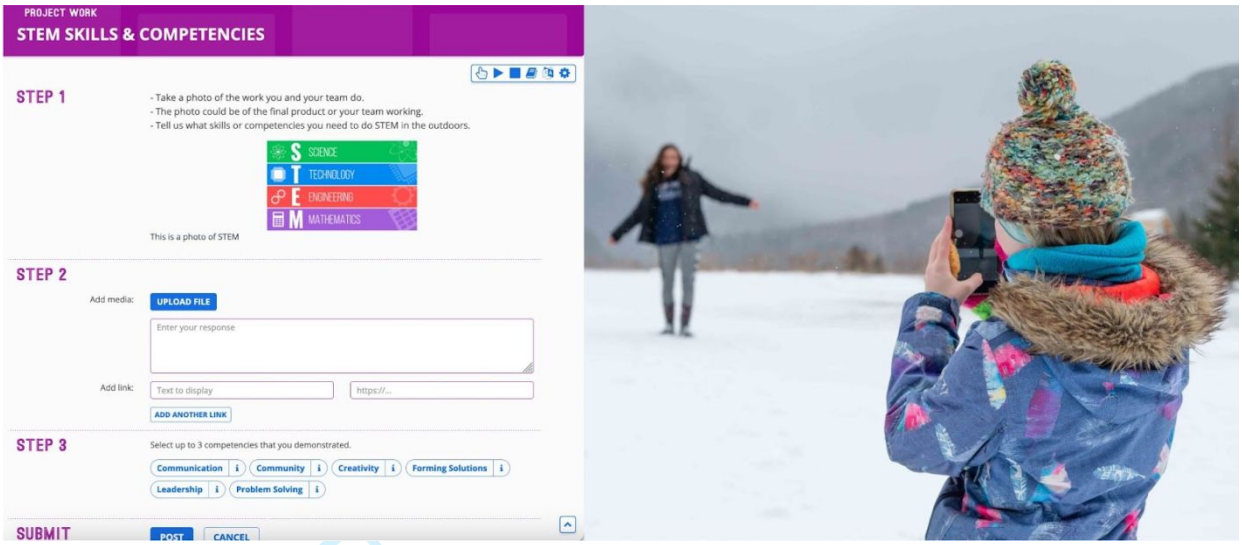


To ensure full engagement, we sought to create experiences that felt personally relevant, valuable, and authentic to rural youth. We viewed this approach as especially critical for supporting STEM identity formation, since "youth who are committed to and highly active in an endeavor are more likely to continue in that endeavor, [and] see it as part of their identity" (Bartko, 2005). Researchers focused on increasing youths' motivation for participation as co-researchers by using a UDL-based app and leveraging tangible strategies from the UDL principle of engagement.

ORfolio

ORfolio is a web-based app that currently exists as an early-stage software prototype, designed with embedded UDL affordances by the [lead organization – withheld for anonymity during review] with National Science Foundation funding. ORfolio served as the primary tool through which youth submitted data and completed their requirements as co-researchers. Through ORfolio, youth were prompted to gather specific evidence (e.g., interview a parent or relative about STEM in the outdoors), share their experience with STEM in the outdoors (e.g., tell us about the STEM you see as you engage in an outdoor activity), and reflect on their experience as co-researchers (e.g., if you could design a challenge for your peers, what would it be and why?). Figure 4 depicts the ORfolio interface and shows a youth participant completing a challenge.

Figure 4
ORFolio Interface and Youth Participant Completing a Challenge

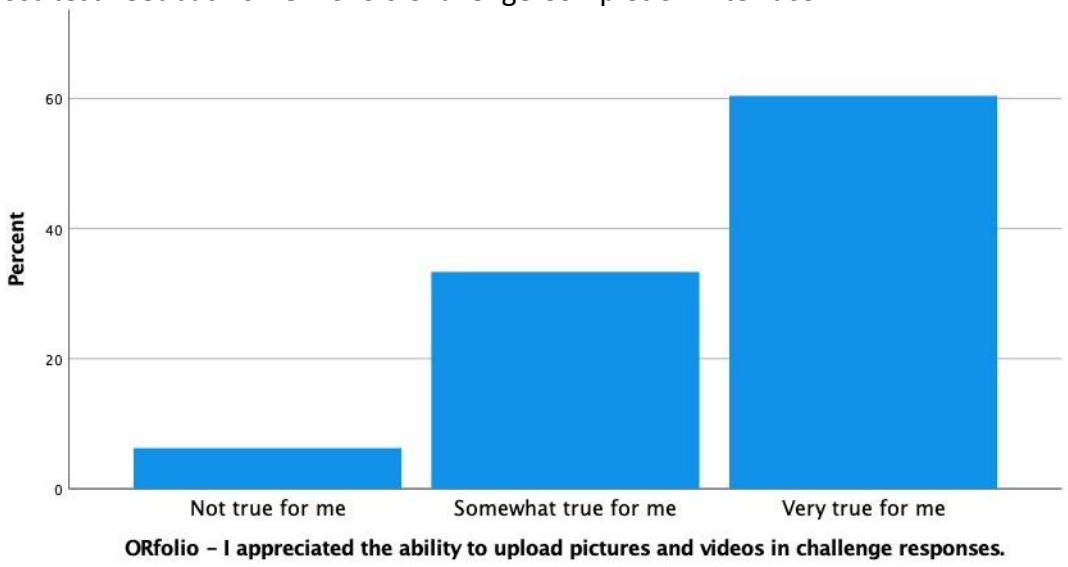


ORfolio was proactively designed to include UDL principles. For example, the app has simple easy to follow directions, a texthelp toolbar with read aloud, translation, and dictionary functions, and the use of multiple means (video, photography, diagrams, text, etc.) for developing challenges and responding to challenges, and responsive web design practices that ensure the digital tool is portable across environments and devices, including tablets and smartphones. For this project researchers built upon the UDL affordances in ORfolio and purposefully utilized UDL engagement strategies to motivate youth in their role co-researchers. UDL engagement strategies included:

- **Increasing opportunities for co-researchers to make decisions and choose how and/when they would engage in the project (UDL Checkpoint: 7.1):** Researchers designed challenges in the ORfolio in ways that offered youth autonomy over how they could gather data, from writing poems to watching videos and interviewing others, as well as the types of data they collected. Researchers also varied the kinds of challenges youth could complete. Some challenges were open-ended and some asked youth to

respond to specific articles or videos. Using ORfolio as a mechanism for data collection provided further flexibility by giving youth control over where, when, and how they completed challenges. Youth reported this kind of "freedom" motivated them. As the chart in Figure 5 illustrates, youth also indicated that having a choice about the type of data they shared positively impacted engagement.

Figure 5
Post-test Feedback on ORfolio's Challenge Completion Interface



- **Highlighting the purpose, meaning, and goals of the project in ways that foster feelings of relevance and authenticity (UDL Checkpoint 7.2).** To optimize the value of being a co-researcher, youth were asked to collect data during activities they were already engaged in or from STEM or outdoor experts they were already familiar with. They were also asked to provide feedback on the research design, challenge options, and the mobile app. As co-researchers, youth reported they were least motivated by the challenges requiring additional reading or those they perceived as more disconnected from their everyday lives. The most engaging challenges were those that required going

outside and the ones they could complete with their family or friends, such as this example:

> *"... my grandfather knows all the ratios and he knows how to identify not just maple trees but all the trees. He also knows when to start and when to stop collecting sap and he just knows everything about making it. My grandfather is an outdoor expert."* — 8th-grade co-researcher

Youth also reported feeling motivated because they were part of something important — or valuable.

> *"I am so happy that I chose to participate in this study! It was very fun to share what I love to do outdoors with the [research] team and experience this with my friends! … I got to do what I love in the outdoors while being a part of a very cool study."* —10th-grade co-researcher.
>
> *"When I look at this data, I feel good because I know that we all went outside and put time into our research. It is fun going over other people's research and how they think."* —7th-grade co-researcher.

The principal investigators sought to build authenticity in the co-researcher role by paying youth and soliciting their insights on the design of the study and the app. Their responses demonstrate engagement, indicating investment in the outcomes of the study. A majority of youth reported feeling motivated by having the opportunity to "earn money from learning" (10th-grade co-researcher). Youth were also highly engaged in opportunities to provide feedback on the app. They made thoughtful

suggestions, including the impact that looking at their peers' data had on their own learning.

> *"It made me feel engaged because he wrote it very well. His (response) makes me wonder what obstacles there were. I think we should look at a specific part of STEM, like math, for the next project."* —10th-grade co-researcher.

As co-researchers, youth suggested improvements to the app such as an in-app reminder to complete challenges and wanting to be able to share challenges through the app with their peers.

> *"When I look at this data in front of me I feel successful because of the improvement and knowledge I gained over the course of the year. This makes me wonder what else I can learn and see in the field of STEM. One thing you should do for the next project is keep accepting feedback and improving on problems that may arrive."* —11th-grade co-researcher.

- **Increasing opportunities for co-researchers to reflect on their experiences and the data, both their own and their peers' (UDL Checkpoint 9.3):** Throughout the project, participants were asked to reflect on their experiences with STEM in the outdoors, participation in the project, their own data, and the findings of the research team. In their role as co-researchers, youth examined challenges from their peers to analyze the depth and quality of the responses. As an 11th-grade co-researcher response illustrates, prompting self-reflection and data analysis foster engagement:

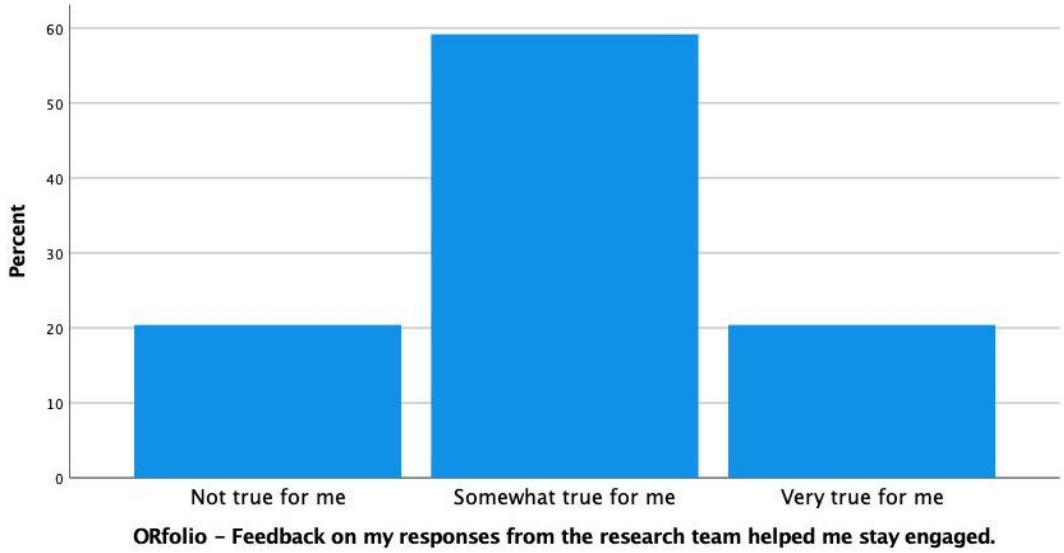
> *"…my responses have changed since the pre-survey, as I think about STEM more and I am more comfortable with it. This makes me wonder if I continued with*

something like this, if I would grow to like STEM even more? I am also curious to see if others had similar outcomes." — 11th-grade co-researcher

UDL emphasizes the importance of making sure youth have opportunity to engage in reflection using a variety of models and scaffolds. For this reason, co-researchers were provided with options and choices for reflection. In addition to challenges that asked co-researchers to reflect in the ORfolio app, they were given the opportunity to reflect in groups through the check-in meetings. This increased engagement, as some youth who did not complete all of the challenges but did attend the majority of the group check-in meetings were able to share more thoughtful reflections on graphic organizers in the group setting.

- **Supporting co-researchers to have a sustained engagement in the project by providing frequent, specific, and timely feedback (UDL Checkpoint 8.4).** Researchers provided feedback using a protocol that ensured each challenge by every participant received encouraging, effort-focused, and identity-related feedback. Co-researchers shared appreciation for the feedback at the final in-person closing event and through the check-in meetings. For example, a 7th-grade co-researcher reported "being able to share (her) experiences and receiving feedback" was one of the most motivating parts of the project. Co-researchers also demonstrated the value of feedback by responding to questions researchers posed in the feedback, thereby completing additional challenges despite not receiving monetary compensation for these responses (see Figure 6)

Figure 6
Students Indicated that Researcher Feedback Helped Stay Engaged



Sample Challenge:

This section includes the text, materials, and student responses collected from co-researchers through the ORfolio challenge: Teach Us About Technology in the Outdoors Challenge.

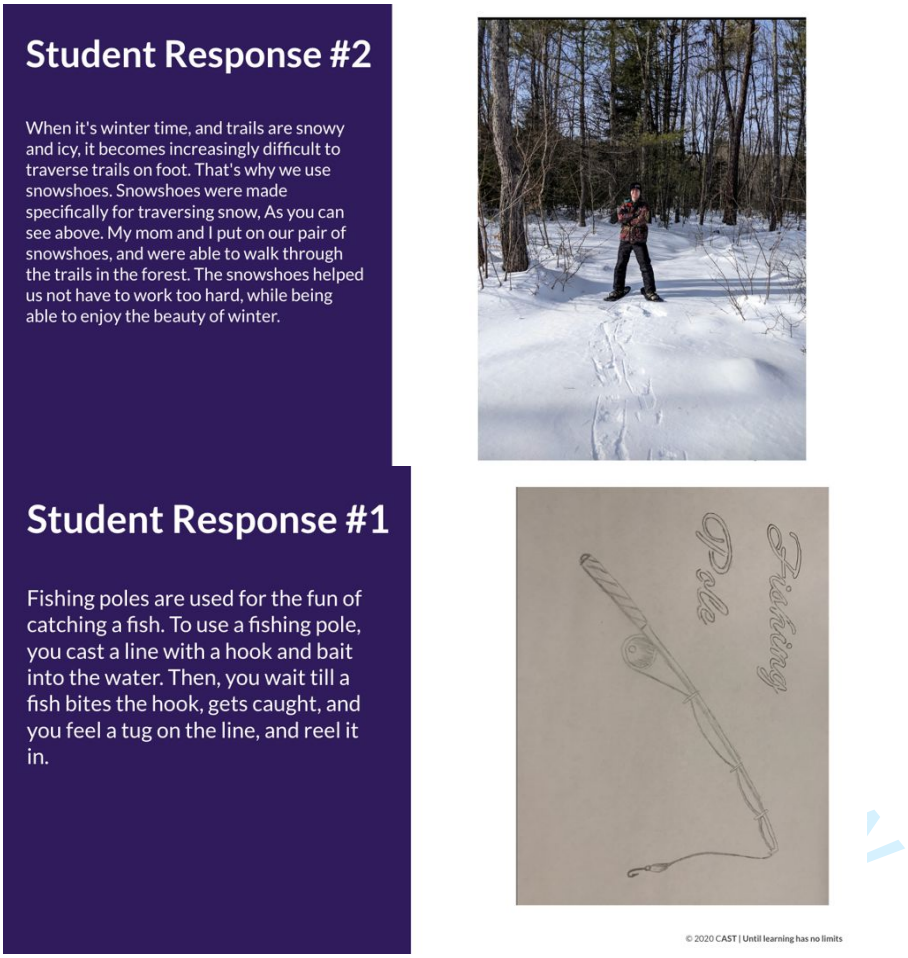
Challenge: This video shows a moose shedding its antlers in the wild (See video link). Read this article to learn more. Wildlife scientists were able to catch the event using a drone. But, drones are not the only kind of technology used outdoors. Remember, technology can be anything from a fishing pole to a camera, from a walking stick to a search-and-rescue dog. Can you teach us about one kind of technology you use outdoors?

Share Your Data

- Take a video explaining the tool and why and how you use it.
- Take a photo of the tool and explain why and how you use it in the feedback section of ORfolio.

- Make a drawing of the tool and explain why and how you use it in the feedback section of ORfolio.

Youth Responses



Outcomes & Recommendations for Future Research

Youth Engagement Patterns

The project achieved a 96% completion rate among youth co-researchers, with one participant moving away and one switching schools. Participants documented their responses through photos, text, videos, and drawings. Over the 10-month research period, 54 youth co-

researchers submitted 630 responses to 25 challenges. Among the 630 challenge submissions, 180 included a picture or drawing and 93 included a video. The most frequently completed challenge was "Interview a Researcher."

In open-ended feedback collected during the culminating event in October 2023, youth reported motivation for completing challenges ranging from "the money" to "getting to do more of what I love in the outdoors" to "seeing all the cool pictures I was able to take." During a May check-in meeting, one participant described the challenges as motivating because they provide the opportunity to reflect on her time outdoors.

> *"I really like getting the chance to reflect on the stuff I do outdoors, and a lot of times I take things for granted and don't think about it very much, so to do the challenges there is an unexpected benefit of them is that I find everything I do outdoors is more memorable when I take time the think and reflect about them."* — 11th-grade co-researcher.

Project Outcomes: Post-Test Results

We used demographic information collected in the sampling survey to create a "disadvantage score" for each participant based on racial, socioeconomic, and ACTE special population factors. Participants were then divided into groups based on whether they were above the mean disadvantage score ("more disadvantages," N=20) or below the mean disadvantage score ("fewer disadvantages," N=32). We used these scores to analyze outcomes on a series of post-survey questions, reported in Table 1 below.

Table 1

Project Outcomes by Disadvantage Group by Mean (SD)

	Group		Gender	

Items (scale: 1=not true of me, 2=somewhat true of me, 3=very true of me)	More disadvantages (N=20)	Fewer disadvantages (N=32)	*p-value*	Boys (N=29)	Girls (N=23)	*p-value*
Average number/percentage of challenges completed (of 14 possible)	7.2 (51%) Min=3 Max=11	6.06 (43%) Min=2 Max=12	.117	6.66 (48%)	6.30 (45%)	.626
I spend more time outdoors as a result of this project.	1.60 (0.50)	1.69 (0.64)	.608	1.76 (0.58)	1.52 (0.59)	.153
This project helped me feel safe outdoors.	2.0 (0.65)	1.72 (0.68)	.147	2.00 (0.66)	1.61 (0.66)	.037
Sometimes in my school classes, I see connections to this project.	2.25 (0.64)	2.19 (0.64)	.734	2.41 (0.57)	1.96 (0.64)	.009
This project helped me see STEM in places I didn't see it before.	2.30 (0.66)	2.2 (0.78)	.594	2.45 (0.63)	1.96 (0.77)	.014
I see adults who work in outdoor recreation in my community differently now.	2.20 (0.62)	1.97 (0.74)	.229	2.28 (0.65)	1.78 (0.67)	.010
Since I have been participating in this project, I have become confident in STEM (Scale: 1-5)	3.35 (0.75)	3.56 (1.22)	.438	3.66 (0.97)	3.36 (1.14)	.184

Although participation rates varied throughout the project, the overall retention rate of 96%, plus findings from the post-project analysis, show promising impacts for leveraging outdoor recreation to develop STEM interest and shape future thinking among rural youth underrepresented in STEM careers. Quantitative data show favorable responses to post-test questions concerning interest in and comfort with outdoor recreation as well as enhanced connections to STEM. Moreover, youth who experience disadvantages to different extents scored comparatively on post-test measures, suggesting the intervention achieved equitable outcomes.

Findings related to gender were notable in that, although girls tend to be underrepresented in STEM careers in general, prior longitudinal research on youth in rural northern New Hampshire found rural boys in particular struggle with activity engagement and postsecondary planning (Sharp et al., 2020; Sharp et al., 2017). Outdoor recreation-based

interventions may therefore hold promise for engaging under-engaged rural boys and impacting their perceptions of future career possibilities including those involving STEM. For example a male co-researcher with a high disadvantage score reported the following about the positive impacts participation in the project had: “It has taught me there is science in everything, not just in class." Another male co-researcher with a high disadvantage score reported, “I would’ve been outside regardless of these challenges, (but because of participation) I definitely noticed more STEM in the outdoors.”

Additional excerpts from project reflections illustrate that youth co-researchers remained engaged and thoughtful about the impact the study had on their perceptions of STEM:

> ***“****Before this project I didn’t want anything to do with STEM, but now I want my future to involve STEM.”* —10th-grade co-researcher.
>
> *“It makes you think of how science is everywhere.”* —8th-grade co-researcher.
>
> *“The skills I have developed through this project are how to notice stuff in the outdoors and how to realize if things that I do involve math or science. Another skill is how to notice people who have STEM involved in their jobs and see if they use STEM in their daily life.”* — 8th-grade co-researcher.
>
> ***Has this project changed the way you think about STEM?*** *“Yes. It has helped me find science in everyday activities. I noticed that sometimes there is science directly involved with all activities, like learning to identify plants, and sometimes you have to look for it, like understanding the physics behind the skating…It has made me think about ways*

math can be used to model real outdoor scenarios, like tracking snowfall or trail use, and help improve our understanding and use of them." —11th-grade co-researcher.

Discussion and Recommendations for Further Research on UDL in STEM Interventions

Study outcomes indicate the feasibility of using outdoor recreation to develop rural youths' STEM identity and career thinking, while also highlighting the importance of collaborating with youth as co-researchers using UDL strategies. More research is needed to better understand how to infuse and analyze the impacts of UDL as a research design tool. For example, seven out of 15 co-researchers reported challenges that mimicked school activities, such as writing and reading components, were demotivating or uninteresting. For example, one participant wrote:

"I was not super interested in writing the poem about an experience outdoors, simply because I write a lot of poems in school and sometimes get tired of them." —9th-grade co-researcher.

"I'm not a big fan of reading articles posted as challenges," —7th-grade co-researcher.

The use of the mobile app to capture youths' involvement in existing activities rather than requiring them to congregate at a program site showed promise for collecting data in out-of-school STEM settings. This was true even in rural communities where Wi-Fi usage might be seen as a potential barrier; only 15% of youth indicated that poor Wi-Fi or cellular service posed a challenge to their involvement. More exploration is needed to investigate the functionality of the mobile app in remote locations and how this impacts their use of specific UDL aspects. For example, very few students used ORfolio features that might deviate from school-based ways

of demonstrating knowledge, such as the speech-to-text feature (only 10% said it was “very true” that this feature helped demonstrate what they know).

Further, while the use of video to submit challenge evidence/data through ORfolio increased during the project, the overall use of video was also lower than expected. Further research will help understand what strategies educators can use to ensure students are aware of and can use UDL supportive media and tools, especially ones that deviate from traditional school-based resources. While co-researchers shared ideas for improving the ORfolio app, further research is needed to understand the motivations behind them, and the cost-benefit of the changes related to rural youth engagement and outcomes.

Conclusion

We believe positioning youth as co-researchers and utilizing UDL strategies to foster engagement had a positive impact on youth engagement and research outcomes. While multiple factors contributed to the high retention rate in this project, such as the use of key adult/community leaders, monetary incentives, as well as researchers with their own local expertise and social capital, the use of the mobile app, designed around UDL as a key structure for engaging youth participants as co-researchers, was significant, novel, and holds promise for future research approaches.

Universal Design for Learning (UDL):

Strategies for Engaging Rural Youth as Co-Researchers in STEM

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