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Skills and Dispositions for PFL: Promoting Data Literacy for Middle School Students in a Summer Camp

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Abstract: We designed a two-week summer camp to support Preparation for Future Learning (PFL) in data literacy by fostering both skills and dispositions. Middle schoolers create data visualization stories to address community-related issues they identified. Analysis showed growth in data visualization skills, self-efficacy, and recognition of data visualization's value. We observed frequent student decision-making, suggesting agency as a key factor. This work prompts future studies on activating agency support PFL for data literacy.

Introduction

Data literacy, the ability to use data for everyday problem-solving is now widely recognized in K-12 education standards (NGSS HS-PS1-1, MS-PS3-1). To support students in applying data literacy beyond the classroom, we must consider how to foster Preparation for Future Learning (PFL)—the ability to transfer and adapt knowledge in new contexts (Bransford & Schwartz, 1999). Promoting PFL in data literacy requires more than building technical skills; it also involves cultivating dispositions such as self-efficacy and recognition of data's value (Driscoll & Wells, 2012). Prior research suggests that engaging students with personally relevant, real-world issues can support both skill and disposition development—especially when students select meaningful topics (Bhargava et al., 2015), work with data connected to their lives (Lee et al., 2021), and communicate findings to authentic audiences (Barron et al., 2014).

To explore how to support PFL in data literacy, we designed a two-week summer camp where middle school students led their own data projects. Students identified questions about their communities, conducted data investigations, created visualizations, and presented their findings to stakeholders. Our mixed-method evaluation showed growth in both skills and dispositions. We also observed that students frequently made intentional choices, revised plans, and negotiated ideas—suggesting their agency was activated throughout the process. Based on these findings, we propose that activating agency may be a key mechanism for fostering both skills and dispositions and therefore, an important design principle for supporting PFL in data literacy.

Skills and Dispositions for PFL

Our summer camp aims to equip students with both the skills and dispositions essential for PFL in data literacy. Existing research suggests that promoting PFL requires not only the development of intellectual skills but also the cultivation of Disposition, such as motivation (Belenky & Nokes-Malach, 2012), self-efficacy (Hemmings & Kay, 2016), and recognition of value (Thornton, 2016). The interplay between disposition and skills is crucial as well. On the one hand, enhanced intellectual skills help students experience success and build confidence, further strengthening their dispositions. On the other hand, dispositions determine how effectively students access, adapt, and apply these intellectual skills, as well as their openness to and willingness to engage in transferring knowledge (Driscoll & Wells, 2012). The cyclical loop between dispositions and skills works together in preparation for future learning. This study takes an innovative approach by examining both skills and dispositions in the context of promoting PFL in data literacy. Our camp is designed to activate students' agency, enhancing their ability to define the problems they want to solve, communicate their ideas to stakeholders, and build motivation and self-efficacy. Additionally, we aim to help students recognize the value of engaging with data, preparing them for future learning and meaningful participation in data-driven environments.

Method

The main goal of the summer camp is to empower students with both data skills and disposition to use data for real-life decision-making and prepare for their future data learning in a project-based learning style with a focus

on real-world, open-ended problems (Swan et al., 2013). During the camp, students would learn the design process of creating data visualizations, use digital tools to create a chart, work on a project that addresses a community-related question through data visualizations, and present their project to community stakeholders. 23 middle school students (Average Age = 12.2, 13 identifying as female) participated in the summer camp. During the first week, students formed into groups of 2-3 students and identified their project topics as they practiced data visualization skills through structured problems. For the second week, students primarily worked with their groups to develop their self-selected projects, with facilitators offering group and individualized scaffolding as needed. On the last day of the camp, students presented their work in posters or other formats they chose to adopt in an exhibition space where parents and community stakeholders were invited.

This IRB-approved study was conducted with the consent/assent of parents/guardians, students, and teachers. Students answered a post-survey self-reporting their experience and growth of skills throughout the summer camp. We also conducted 5-6-person focus groups with campers with parental consent and assent. Focus groups were audio recorded and transcribed for analysis. Camp sessions, including the final presentations, were video recorded and transcribed. We also collected worksheets and the final projects created by the students during the camp. We used Braun and Clarke's (2006) theoretical thematic analysis to qualitatively code the data.

Findings and Discussion

To understand how students' data skills improved, we examined the types of charts they planned in their project planners and those they ultimately used in their final artifacts. In their project planners, students predominantly chose bar charts (46.7%). By the final presentations, they had expanded to a range of formats: bar charts (38.9%), real-world glyphs (13.9%, e.g., raindrops, trash bags), maps (8.3%), and creative formats (19.4%, e.g., hand-drawn illustrations, videos, games, 3D prints). These more creative visualizations demonstrated that students were thinking beyond traditional statistical charts and utilizing their creativity and expertise to communicate their ideas. By not limiting students to certain types of charts, they had the opportunity to evaluate and compare their design decisions, allowing them to compare design ideas to support their communication and make their presentations more engaging and relatable for community stakeholders.

To understand how their disposition improved, we evaluate students' growth in self-efficacy and recognition of data visualization value through a quantitative analysis of students' surveys and an inductive analysis of the focus group transcript. In the post-survey, students rated their perceived growth across nine data literacy skills using a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). Students reported increased self-efficacy across all nine data literacy items Notably, over 18 students rated 4 or 5 for statements such as "I can find appropriate data sources," "I can use data to answer questions important to my community," and "I can use visualization to make data easier to understand." These three skills are highly relevant to the students' self-selected personally relevant project practices, demonstrating a high self-efficacy in applying data skills to personally meaningful contexts, which is a critical factor for their long-term engagement with data.

We also evaluated how students value data visualization by reviewing their responses to focus group questions about *"how data visualizations could be helpful for your community"* and "*how data visualization might help you in school or future careers".* We identified eight themes related to the value of data visualization from these two prompts. From the Personal Value perspective, students highlighted data visualization's benefits for satisfying curiosity (3), helping learn school subjects (4), and helping clarify information (3). From the Community Value perspective, students highlighted data visualization's benefits for improving information accessibility (6), engagement (2), and trustworthiness (1)—all viewed as the advantages of utilizing data visualization for communication. Through their project experiences, students developed a deeper appreciation for how data visualization could benefit their community.

During the analysis of students' growing skills and dispositions, we also identified patterns when students actively made decisions, restructured their projects, and negotiated with their peers to refine their projects. For example, for the team that addressed the *School Lunch* issue, one student initially proposed a general school-related topic, while another suggested fast food. Although these initial questions lacked full support from the group, one student reported that the team "*compromised it so it could be something that we all really wanted to do*." This process of negotiation and comparison allowed the team to arrive at a more focused question, tailored to their shared interests. These patterns led us to hypothesize that activating student agency may correlate with both skill development and disposition growth, two core elements of PFL. In future iterations, we plan to implement validated instruments (e.g., Damşa et al., 2010; Hardy et al., 2020) to directly measure agency and analyze its relationship with PFL more systematically. This will allow us to evaluate the relationship between agency, skills, and dispositions and, therefore better analyze the relationship among agency, skills, dispositions, and PFL. This may offer insights for researchers and educators in other domains, supporting efforts to promote knowledge transfer for real-world problems through activating students' agency.

References

Barron, B., Schwartz, D. L., Vye, N. J., Moore, A., Petrosino, A., Zech, L., & Bransford, J. D. (2014). Doing with understanding: Lessons from research on problem-and project-based learning. In Learning through problem-solving (pp. 271-311). Psychology Press.

Belenky, D. M., & Nokes-Malach, T. J. (2012). Motivation and transfer: The role of mastery-approach goals in preparation for future learning. Journal of the Learning Sciences, 21(3), 399-432.

Bhargava, R., Deahl, E., Letouzé, E., Noonan, A., Sangokoya, D., & Shoup, N. (2015). Beyond data literacy: Reinventing community engagement and empowerment in the age of data.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (2000). How people learn (Vol. 11). Washington, DC: National academy press.

Bransford, J. D., & Schwartz, D. L. (1999). Rethinking transfer: A simple proposal with multiple implications. Review of Research in Education, 24(1), 61-100.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qual. Research in Psych., 3(2), 77–101.

Damşa, C. I., Kirschner, P. A., Andriessen, J. E., Erkens, G., & Sins, P. H. (2010). Shared epistemic agency: An empirical study of an emergent construct. The Journal of the Learning Sciences, 19(2), 143-186.

Driscoll, D. L., & Wells, J. (2012). Beyond knowledge and skills: Writing transfer and the role of student dispositions. In Composition Forum (Vol. 26). Association of Teachers of Advanced Composition.

Hardy, L., Dixon, C., & Hsi, S. (2020). From data collectors to data producers: Shifting students' relationship to data. Journal of the Learning Sciences, 29(1), 104-126.

Hemmings, B., & Kay, R. (2016). The relationship between research self-efficacy, research disposition and publication output. Educational Psychology, 36(2), 347-361.

Lee, V. R., Drake, J., Cain, R., & Thayne, J. (2021). Remembering what produced the data: Individual and social reconstruction in the context of a quantified self elementary data and statistics unit. Cognition and Instruction, 39(4), 367-408.

Next-generation science standards. (2013). https://www.nextgenscience.org/

Swan, K., Vahey, P., van't Hooft, M., Kratcoski, A., Rafanan, K., Stanford, T., ... & Cook, D. (2013). Problem-based learning across the curriculum: Exploring the efficacy of a cross-curricular application of preparation for future learning. Interdisciplinary Journal of Problem-Based Learning, 7(1), 8.

Thornton, H. (2006). Dispositions in action: Do dispositions make a difference in practice?. Teacher Education Quarterly, 33(2), 53-68.

Van't Hooft, M., Vahey, P., Swan, K., Kratcoski, A., Cook, D., Rafanan, K., ... & Yarnall, L. (2012). A cross-curricular approach to the development of data literacy in the middle grades: The thinking with data project. Middle Grades Research Journal, 7(3), 19.

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