Technology-Mediated Lesson Study: Improving Rural Science Teachers' Three-Dimensional Science Teaching Practices

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Abstract

As science education evolves to three-dimensional (3D) science, rural science teachers often lack the same professional development and training as their urban counterparts due to isolation and other factors. One method that can help teachers improve their teaching skills is lesson study, which allows educators to co-create and evaluate lessons as a group. By using technology-mediated lesson study, rural science teachers can connect with geographically distant others and collaborate to build new collegiate connections and gain knowledge and skill with 3D science principles. Preliminary interview and observation data suggest rural teachers are making meaningful connections and iteratively improving their ability to plan and teach 3D science lessons.

Keywords: NGSS, lesson study, rural science education, STEM education

Introduction

Science education in the United States is transforming toward a model that comprises three dimensions (3Ds): science and engineering practices, crosscutting concepts, and disciplinary core ideas (SEPs, CCCs, and DCIs) (NGSS Lead States, 2013). Central to the new standards is the principle that students must make sense of science in a 3D way that combines the SEPs, CCCs, and DCIs with the goal of richer, more authentic learning experiences. In one western state, urban school districts have implemented these standards for several years, including training high school science teachers in 3D science teaching; however, most rural teachers in the state have received very little training on the new standards. The program described here addresses rural science teachers' lack of professional learning opportunities by using technology to bridge the geographic isolation they experience.

Primary Goals of the Research

This research has three goals: first, *principles*: an innovative model for rural science teacher professional development via technology-mediated lesson study that supports translating professional learning into classroom practice through social support systems; second, *people*: building expertise, capacity, and collaboration among the rural science teachers to support 3D science teaching; and, third, *products*: creating and disseminating high-quality 3D science lesson plans aligned with state standards and the Next-Generation Science Standards that will be shared with teachers across the country.

Conceptual Framework

The research design is built on an ecological model described by Sallis et al. (2008) for changing health behaviors and is applied to changing teaching practices to incorporate three-dimensional science teaching. Teachers choose instructional practices based on personal factors (e.g., attitudes, self-efficacy), social factors (e.g., peer, administrator, and student expectations), and contextual factors (e.g., physical, material, and time resources). The program targets personal factors by supporting rural science teachers' development of knowledge, self-efficacy, and positive attitudes about three-dimensional science teaching. Social factors via cohorts of subject-region teams provide a sense of community and support for the instructional changes needed for the new state standards.

Professional Development

To teach the new standards in the most effective ways, ongoing professional development and training are needed. One beneficial element of professional development for instructors is ongoing, collaborative, practice-based learning. However, rural teachers, in particular, struggle to find meaningful collaboration due to the unique factors of where they teach, such as being the only instructor in their field (e.g., physical science) or a specific subject (e.g., biology) in their school. Many rural teachers also experience considerable geographical distance from other educators teaching the same subject. Often, rural teachers also have additional responsibilities besides teaching (e.g., coaching, administrative work, etc.) that can take time away from developing lessons aligned with new standards. Teachers in rural districts also have reduced access to professional development opportunities (Banilower et al., 2018). All these factors can make this robust collaboration between colleagues difficult.

Lesson Study

One method of helping educators create collaboration for professional development is Lesson Study. Originating in Japan, lesson study is an instructional inquiry model rapidly spreading worldwide (Lewis & Hurd, 2011). The lesson study process involves a group of educators coming together with shared goals for student learning and co-create lessons to meet those goals. The basic format of lesson study is that the produced lesson is taught to students in the group's presence. The group then meets to discuss what was observed about student learning, the teaching process, and the lesson itself. These steps are repeated, creating a cyclical experience that develops educators' knowledge and motivation for teaching and helps develop a robust professional learning community (Lewis & Hurd, 2011; Murata, 2011). The dual focus on both long-term goals (e.g., improving the teaching of three-dimensional science) and the current lesson under review (e.g., the transfer of energy in a system) creates a dynamic professional development system for teachers to improve their teaching and learning.

Four essential teaching tasks—designing lessons, teaching, observing and analyzing student responses, and reflecting on implications for future lessons—are all foci of the lesson study process (McDougal, 2022). Lesson study slows down the lesson creation process, allowing teachers to concentrate on critical elements, such as the planning and reflection stage, to which they may not otherwise devote significant time. They are also given opportunities to observe another teacher's lesson—an opportunity that, for many teachers, is not frequently available. Watching someone else teach allows the observers to focus on student learning and misconceptions, which teachers can miss while teaching due to divided focus across an entire class. This close observation can help the teachers think about the design process and how to improve the lesson so misconceptions can be addressed.

Technology-Mediated Lesson Study

Researchers have noted that one of the practical difficulties of lesson study in the modern American classroom is accommodating teaching and teacher schedules to fully invest in a lesson study group (Choppin et al., 2020; Huang, 2020; Soto et al., 2019). However, for rural teachers, not only is it hard to match schedules, it can be near impossible to meet with other teachers in the same field as there can be considerable distances between schools. Previous social network analysis indicated that teachers were more likely to collaborate with teachers located in the same school or district (Poulsen et al., 2022). This is effective for larger districts, where teachers may have access to

multiple other science teachers with whom to collaborate. However, in smaller districts, there may only be one or two high school science teachers, so opportunities for collaboration are minimal.

Technology-Mediated Lesson Study (TMLS) utilizes technology resources to allow teachers to interact and learn together when not co-located. This interaction among remotely isolated teachers connects them with colleagues they otherwise would have no connection with, including those in other districts. These new virtual teacher groups collaborate through technology-mediated means to create robust 3D science lesson plans that are refined through the lesson study process. This happens by meeting together virtually to refine lesson plans aligned to 3D science principles, having one team member record the lesson as it is taught to students by recording what the teacher says, where the teacher goes in the classroom, as well as student conversations that can all be viewed remotely and asynchronously by utilizing SWIVL technology (see swivl.com). The lessons are reviewed asynchronously by other team members, who then meet virtually to discuss and revise the lesson.

Method

Twelve rural science teachers were recruited and given in-person professional developmental instruction in the principles of 3D science and the lesson study process. They were divided into three groups of four teachers (based on geographical regions) and worked together to develop high school biology lessons aligned with state standards incorporating 3D science elements. One teacher in each group recorded themselves teaching the lesson to their students by using the Swivl robot. Other group members reviewed each lesson and then met virtually to discuss what they watched and make revisions to the lesson plan. This process was then repeated for each subsequent teacher, taking turns teaching the revised lesson and coming together as a group to revise again and review the lesson.

Participants' reflections about the TMLS process and their participation in the teacher groups were taken from both formal interviews and comments made during group meetings. They were analyzed to evaluate the TMLS process from the view of the participants to answer the following questions:

1. How is the process of TMLS helping rural science teachers make meaningful professional connections?
2. How does TMLS help in the development of understanding 3D science for teachers?

Results

High school educators involved in the TMLS process indicated that the new collaboration from these teacher groups had a positive effect on making new professional collaborations and connections. One participant expressed how he valued the collaborative process saying, “It was really nice for me just to be able to shoot ideas off of people, to listen to other people's perspectives, and gain a deeper understanding [of] struggles that other teachers are having. It's been a really good experience for me overall.” Another participant explained how he felt more comfortable with the other group members to the point where he is excited to share this experience with new teachers beginning the TMLS process saying, “We've gone from all of us kind of being in an awkward situation with each other, not being comfortable teaching around each other, kind of feeling each other out to now, I'm excited for the opportunity to teach in front of teachers I've never met and be able to show them what we are really doing and what the expectations are.”

Improved collaboration was also observed during the TMLS meetings. Group conversations showed participants felt comfortable with each other, as indicated by their willingness and openness to share personal details of their lives and joke with each other. Teachers also commented how collaboration became a substitution for having multiple science teachers in the same school. One teacher noted, “This has been the best professional development I’ve been involved in. Because of [other group members,] I can see the value in what we are doing. I can see the advantage of having three or four teachers in the same subject in a school.” One teacher said she wants “to replicate this process with my department,” indicating the value of the professional development.

Teachers also indicated that the TMLS process changed their thinking regarding 3D science. Teachers specified that this process has, for the first time, allowed them to thoroughly think about all aspects of three-dimensional science and helped them improve their process when developing science lessons for students with one teacher saying, “Doing lesson studies and actually breaking it down caused me to rethink a lot of how I incorporate not just the disciplinary core ideas, but the crosscutting concepts and engineering practices. It's caused me to do a complete rethink in making sure I ask those questions: Am I surface learning? Or am I going to transfer with this?” A final way that the process helped teachers improve their understanding of 3D science was by watching other teachers instruct students using the team’s lesson plan. One teacher expressed how he liked seeing other teachers

teach the lesson before him and seeing that improved his teaching saying, “Anytime you can build a lesson plan and then implement that lesson plan, I think that's going to encourage growth. Watching all of the other teachers on Swivl and …going through that process helped a lot in just in my own instruction.” These results show that creating, discussing, and revising a lesson plan that uses 3D science principles with a group of other science teachers can help improve how each teacher views their ability to teach with these principles in their classes.

Conclusion

Technology-mediated lesson study assists rural science teachers in developing new connections with other teachers they otherwise would not have any contact with, and preliminary data from interviews and observations of group discussions indicate that the teachers value these connections as well as the TMLS process. Some even indicated wanting to incorporate this process with others in their schools. Data also suggests that the TMLS process —including watching others teach the co-created lessons—is helping teachers learn 3D science better and improve how it is incorporated into their classes. Future studies will further explore how the TMLS process helps connect rural science teachers on an ongoing basis and how teachers can integrate 3D principles to change how they teach science.

References

Banilower, E. R., Smith, P. S., Malzahn, K. A., Plumley, C. L., Gordon, E. M., & Hayes, M. L. (2018). Report of the 2018 NSSME+. *Horizon Research, Inc.*

Choppin, J., Amador, J. M., Callard, C., Carson, C., & Gillespie, R. (2020). Synchronous online model for mathematics teachers' professional development. In *Handbook of research on online pedagogical models for mathematics teacher education* (pp. 176-202). IGI Global.

Huang, R., Kimmins, D., Winters, J., & Rushton, G. (2020). Does a technology-assisted lesson study approach enhance teacher learning while eliminating obstacles to traditional lesson study? Contemporary Issues in Technology and Teacher Education, 20(4), 618-659

Lewis, C. C., & Hurd, J. (2011). *Lesson study step by step: How teacher learning communities improve instruction.* Heinemann.

McDougal, T. (2022). Learning from Lesson Study as part of the planning team. In A. Takahashi, T. McDougal, S. Friedkin, & T. Watanabe (Eds.) *Educators' Learning from Lesson Study* (pp. 13-18). Routledge.

Murata, A. (2011). Introduction: Conceptual overview of lesson study. In L. Hart, A. Alston, & A. Murata (Eds.) *Lesson study research and practice in mathematics education* (pp 1-12). Springer.

NGSS Lead States (2013). *Next Generation Science Standards: For states, by states.* National economic press. www.nextgenscience.org.

Poulsen, T., Sansom, R., Leary, H., Stowers, J., & Longhurst, M. L. (2022). Factors describing the formation and strengths of ties between rural science teachers. Paper presented at the *Northern Rocky Mountain Education Research Association Conference*, Billings, MT.

Sallis, J. F., Owen, N., & Fisher, E. B. (2008). Ecological models of health behavior. In K. Glanz, B. K. Rimer, & K. Viswanath (Eds.), *Health behavior and health education: Theory, research, and practice* (pp. 465–485). Jossey-Bass.

Soto, M., Gupta, D., Dick, L. & Applegate, M. (2019). Bridging distances: Professional development for higher education faculty through technology-facilitated lesson study. *Journal of University Teaching and Learning Practice*, *16*(3), 1-19.