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The Implementation of Interdisciplinary Science Inquiry of Biology Teachers Compared to Physical Science Teachers

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ISEP Interdisciplinary Science and Engineering Partnership

Abstract

The *Next Generation Science Standards* provides a new framework that solidifies the importance of teaching interdisciplinary STEM courses. Specifically, the National Research Council has argued for the need to make biology education more interdisciplinary. Since biology teachers seem to have the most difficulty teaching interdisciplinary STEM, a comparative case study was conducted to understand which factors influence interdisciplinary teaching, and, if there are differences between biology and physical science teachers. Using the framework of interdisciplinary science inquiry (ISI), seven high school science teachers were compared to understand how professional development and subject pedagogical content knowledge informed their implementation of ISI. Findings of the study revealed a range of levels of implementation, with no notable differences between science teachers from different content backgrounds. Rather, there were common factors, such as time limitations due to the curriculum, and a teacher's understanding of, and value placed on ISI, which affected their implementation. Based on the results of this study, it seems that further efforts need to be made to help teachers develop a better understanding of what ISI is. In addition, teachers need to develop their subject content knowledge in all of the sciences, better enabling them to make interdisciplinary connections.

Research Questions

Due to the call to teach modern biology as interdisciplinary (NRC, 2003; NRC, 2009) and the struggles that biology teachers have in particular to implement interdisciplinary STEM (Asghar et al., 2012), the following research questions have been developed. These research questions are based on the context of a partnership that provides professional development in the form of summer research and professional learning community (PLC) experiences, which is meant to promote the teaching of interdisciplinary science and engineering.

(1) How does the summer research experience and participation in the monthly professional learning communities during the academic year impact the implementation of interdisciplinary science inquiry (ISI) by biology teachers compared to teachers in the physical sciences of earth science, chemistry, and physics?

(2) What relationship, if any, is there between teacher subject pedagogical content knowledge and the implementation of ISI by biology teachers compared to teachers in the physical sciences of earth science, chemistry, and physics?

(3) What challenges do biology teachers encounter in implementing ISI compared to teachers in the physical sciences of earth science, chemistry, and physics?

Materials and Methods

- This study utilized a mixed-methods approach to build a comparative case study. The participants in this study consisted of seven in-service teachers from various high schools in a large urban school district in the Northeastern United States. These teachers are a part of an NSF-funded program that provides professional development in the form of summer research and PLC experiences.

- Quantitative and qualitative data
  - Online pre- and post-test on subject pedagogical content knowledge
  - Attendance records from the past three years (2012-2015) were used to classify PLC attendance as high, medium, or low.
  - Observations of the teachers' summer research experiences and classroom lessons
  - Semi-structured interviews
  - Artifacts collected during classroom observations: teacher lesson plans, student handouts, digital photos
  - Teacher summer research logs and ISI implementation posters

Results

- Since there were seven different teacher cases, a detailed description of each case was described. Each source of data – the pedagogical content knowledge (PCK) test, observations, interviews, and artifacts – were analyzed to build each case. A cross-case synthesis was used to find similarities and differences among the cases (Creswell, 2013).
- In analyzing the results from the seven different case studies, it can be seen that there is not a difference in the implementation of ISI between the different science subject content teachers. Although the two biology teachers have a very low implementation of ISI in their classes and mostly limit their implementation to replicating their summer research experience in an after school club, similar types of results are also seen with some of the other subject content science teachers. All of the teachers have varying ideas on what ISI is and what it should look like when implemented. Rather than analyzing the results separately by science teacher subject, the results were analyzed as a whole, regardless of what science class they teach, as to factors that either promote or inhibit the implementation of ISI across all sciences. An overview and summary of the seven different science teachers can be found in the table.

Teacher (Current subject taught)	Certifications	Subjects Taught	PLC attendance	PCK pre-test (post-test)	Beliefs in purpose as a science teacher and what ISI implementation looks like	Implementation of summer research and ISI
Matt (Physics)	physics	physics, chemistry, biology, earth science, environmental science	High	97% (93%)	Connect science to everyday lives; ISI as students learning connections between sciences and hands-on activities; student-driven questions; student-centered inquiry-based curriculum	No implementation of summer research; high implementation of ISI
Tom (Physics)	biology, general science, physics	biology, environmental science, physics	Low	59% (59%)	Get students to pass the state exam; ISI as including math in physics and connecting science and engineering; inquiry as students struggling to solve physics problems; hands-on labs	No implementation of summer research or ISI in class; limits implementation to after school science club
Zack (Chemistry)	biology, chemistry	chemistry, biology	Medium	93% (93%)	Get students to look at things critically and find answers; ISI as incorporating different sciences, but also making connections within chemistry and the real world; inquiry as students doing a lab the best they can and coming up with their own data and conclusions	Very low implementation in lab; mostly implements in after school science club
Julie (Chemistry)	chemistry, general science	middle school life science and physical science, chemistry	Low	87%	Relate chemistry to their everyday lives; interdisciplinary as making connections to math and ELA, and inquiry as students investigating on their own; students write their own lab procedures	Implements summer research in class; implements inquiry in lab, but no interdisciplinary science
Paul (Biology)	biology	biology, chemistry, earth science, environmental science, middle school life science and health	Medium	86%	Students become scientifically literate citizens and do something that is real; ISI as incorporating math and engineering into problem solving; people of different specialties working together; inquiry as student-centered problem solving; ISI implementation mostly as replicating summer research experience	Very low implementation in biology class; some implementation of ISI in environmental science class; implementation mostly limited to after school science club by replicating summer research experience
Jennifer (Biology)	biology, elementary education	biology, environmental science	Low	55% (55%)	Get students involved in science; get students to pass state exam; ISI as bringing together different sciences and having students find answers; ISI implementation as replicating summer research experience, having students learn lab procedures, and having students do more hands-on activities	Very low implementation in lab; implementation mostly limited to after school science club by replicating summer research experience
Michael (Earth science)	earth science, biology, general science, elementary education	earth science, biology	Medium	77% (63%)	Get students to gain a better understanding of the different sciences and the world around them; hands-on projects; interdisciplinary as using math and ELA in science and fitting physics and chemistry in earth science	Implements summer research in lab; implements inquiry almost every day through bell-work questions based on the topic students will learn that day

Conclusion

With the realization of the importance of teaching interdisciplinary science, comes the importance of preparing teachers to teach in this manner. Even though the teachers in this study have been provided with professional development, it is clear that there are still several factors that are limiting teachers from fully implementing ISI in their classrooms. Many resources will need to be provided to teachers to help with the implementation of the new *NGSS* standards (NGSS Lead States, 2013), which will most likely include changes in instruction and assessment. Based on the results of this study, it seems that further efforts need to be made to help teachers develop a better understanding of what interdisciplinary science teaching is, and to provide some more specific resources to help them with the development of curriculum materials that promote the teaching of ISI. It seems that teachers also need to develop their subject content knowledge in the sciences outside of those that they are certified in, better enabling them to make interdisciplinary connections. Even though this study did not show a difference in the implementation of ISI among biology teachers compared to the physical science teachers, it is something that should be considered with a larger sample size of teachers. It seems that the teachers in this study, regardless of what science they teach, seem to have difficulties making interdisciplinary science connections. With states in the process of adopting the *NGSS*, there is clearly a lot of work that will need to be done to prepare for interdisciplinary science teaching.

Literature Cited

Asghar, A., Ellington, R., Rice, E., Johnson, F., & Prime, G.M. (2012). Supporting STEM education in secondary science contexts. *The Interdisciplinary Journal of Problem-based Learning, 6*(2), 85-125.

Creswell, J.W. (2013). *Qualitative inquiry and research design: Choosing among five traditions*. Sage Publications.

National Research Council (2003). BIO2010: Transforming undergraduate education for future research biologists. National Academies Press: Washington, DC.

National Research Council (2009). A New Biology for the 21st century: Ensuring the United States leads the coming biology revolution. Washington, DC: National Academies Press. www.nap.edu/catalog.php?record_id=12764

NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States*. Achieve, Inc. on behalf of the twenty-six states and partners that collaborated on the NGSS. Washington, DC: National Academies Press.

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