Fostering Scientific Habits of Mind: Sharing the "Best" of NASA Endeavor in the Hockinson School District

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Introduction

Not long ago, I received an e-mail from a colleague describing a program designed to assist teachers improve STEM (science, math, engineering and technology) teaching in the classroom, NASA's Endeavor Science Teaching Certificate Project. I was excited to apply; seeking out professional development with access to the most current understandings of science content and teaching keeps what is happening in the classroom up-to-date and dynamic. At the time, I knew that I would soon have to choose between National Board Certification or Professional Certification in my home state of Washington to satisfy renewal requirements for my Residency certificate. I thought I could meet either challenge; however, I knew that there was so much for me to still learn about science content knowledge and pedagogy. I questioned whether or not the process of certification alone would be enough to improve my skills. I applied for a NASA Endeavor Fellowship, was selected, and have spent the last fifteen months engaged in STEM content and pedagogy coursework and in a nationwide professional learning community made-up of in-service and pre-service teacher Fellows, Endeavor instructors, and NASA scientists.

One of the many benefits of participating in this program has been the access to high quality, current resources. I recently had a conversation with a veteran science teacher (S. Thompson, personal communication, January 20, 2011) in my building about how I was using real-time data from NASA and the USGS in the classroom. He commented that what we needed as a science team was assistance in knowing what is "out there" in terms of web resources, NASA assets, and science content support. This conversation echoed Marrero, Woodruff, and Schuster's (2010) comments that teachers of science seek up-to-date resources for professional development. Science is a dynamic and exciting field in which new information is constantly forthcoming; science educators need access to up-to-date research and curricular materials ready to be implemented in classrooms. (p.81).

Having read in the National Science Educational Standards (1996) that "working as colleagues, teachers are responsible for designing and implementing the ongoing professional development opportunities they need to enhance their skills in teaching science, as well as their abilities to improve the science programs in their school" (p.52), I decided that I would develop a professional development workshop that would get the teachers in my district, kindergarten through tenth grade, connected to outstanding web resources that I had learned of during my Endeavor Fellowship. The goal of this project and study was to increase my colleagues' exposure to real-time data and other web resources, including NASA resources, to assist them in developing an "enhancement" for a lesson or science concept, and then to provide them the time and opportunity to share their enhancements and the results of implementing them. My premise was that if given the opportunity to explore on-line resources and receive guidance while making manageable modifications to existing lesson plans, teachers would gain confidence in incorporating real-time data and on-line resources to future lesson plans. However, in the process of developing the professional development workshop, the focus of the project began to evolve.

Evolution of the Project

Similar to educator field experiences like *Teachers in the Woods*, it was the goal of this project "to broaden the concept teachers ha[ve] of themselves as science teachers and provide the necessary confidence to lead students through similar research projects" (Dresner & Worley, 2006, p.2).

With this premise in mind, I set out to develop a two day professional development workshop for my science colleagues across the Hockinson School District, extending the invitation to grades kindergarten through tenth grade. The structure of the workshop was such that the first day would consist of individual presentations on separate days to each grade band: kindergarten through second grade, third through fifth grade, and a combined meeting of sixth through tenth grade teachers. The second workshop day was scheduled approximately one month after the first and was structured as a vertical K-10 collaboration. While the structure of the workshop essentially stayed the same from the initial design to the final product, the content and focus of the workshop shifted dramatically.

I began with the idea that providing professional development that assists science teachers in accessing real-time data on the internet, as well as other web resources, and models how to make "small" modifications to existing lesson plans using these data, would empower teachers to create "meaningful, real-world research activities for the class, modeling the behavior of professional scientists, and enabling students to collect and analyze real-world data" (Dresner & Worley, 2006, p.1). Although, through peer debriefing with teacher colleagues and administrators, I realized that this focus might not meet the diverse needs of science teachers in my district. One of the concerns brought to my attention was that integration of any science at the elementary level is sometimes problematic given the demands of teaching literacy and mathematics. Another concern expressed was that preparation for the state test at the elementary and secondary level is absorbing large quantities of time so adding one more new thing just isn't reasonable. Finally, I was made aware that some of my colleagues in the district were not comfortable using the computer and, more importantly, there were some who were uncomfortable teaching science. These concerns were valid as they are shared concerns in education.

Improving science teaching and students' performance is part of the on-going national, state, and local conversation of how to improve public education. From his appearance on Discovery Channel's "Mythbusters" (2010) to his State of the Union Address (The White House, 2011), President Obama has vocally supported improving STEM teaching and learning. In his address, President Obama stated that "with so many baby boomers retiring from our classrooms, we want to prepare 100,000 new teachers in the fields of science and technology and engineering and math" (para. 6). In addition, President Obama's "Educate to Innovate" plan (2010) outlines the following:

> President Obama has identified three overarching priorities for STEM education, necessary for laying a new foundation for America's future prosperity: increasing STEM literacy so all students can think critically in science, math, engineering and technology; *improving the quality of math and science teaching so American students are no longer outperformed by those in other nations* [italics added]; and expanding STEM education and career opportunities for underrepresented groups, including women and minorities (The Initiatives section, para. 4).

While improving the quality of math and science teaching is a national priority, how to define and bring about that improvement is a point of debate.

> The current educational culture of accountability has revamped the definition of teacher quality. In this culture of quality, teachers are largely responsible for their own professional development--often in order to maintain their state certification and their delineation as "highly qualified." (Marrero, et al., 2010, p.81)

In the *National Science Education Standards* publication, the National Research Council (1996) concur in this assessment of teacher responsibility of self-initiated professional development:

> Although some teachers might choose involvement at the district, state and national levels, all teachers have the professional responsibility to be active in some way as members of a science learning community at the school level, working with colleagues to

> improve and maintain a quality science program for all students. (National Research Council, 1996, p.51)

Are there barriers that make it difficult for teachers to participate in quality professional development and to implementing change into their practice? According to Dresner and Worley (2006), "sufficient time, resources, and support are required to sustain change in classroom practices" (p. 2). Even as my Endeavor Fellowship draws to a close, I am concerned that I may forget or neglect what I have learned; will I sacrifice reflection-based improvements in my practice to what is quick and familiar given the fast-paced rhythm of my profession? For teachers to make meaningful improvements to their teaching practice, personal responsibility of organizing and participating in quality professional development must have the support of their district (National Resource Council, 1996, p.52).

In the spirit of the art of teaching, I modified and adjusted my vision to match and expand the focus of this project in order to address these concerns. Instead of only sharing the real-time data sources and web resources from my NASA Endeavor experience, I decided to frame these Endeavor resources and other "best practices" under the larger umbrella of the innovative and imaginative nature of science (AAAS, 1989, Chap.12). The content of the workshop centered on what are scientific "habits of mind" and how we can foster them across K-10 curricula. In *Science for All Americans* (1989), a scientific thinker reveres curiosity, logic, and imagination and that "these values, attitudes, and skills can be thought of as habits of mind because they all relate directly to a person's outlook on knowledge and learning and ways of thinking and acting"(Chapter 12, para. 1). In the 2010 draft of the revised National Science Education Standards, scientific habits of mind include observing and experiencing; asking questions; making predictions and models; collecting, analyzing and interpreting data; discussing and arguing ideas; giving and receiving feedback; reading, writing and communicating findings, and using what you have learned. These scientific habits of mind are everyday life practices, accessible to the youngest and oldest of students. It is my belief that these ideas are at the heart of developing an informed community of independent thinkers who respect their interdependent relationship with the Earth. And so, my essential research question evolved: how does sharing NASA Endeavor "best practices" with the focus on fostering scientific habits of mind impact kindergarten through high school Hockinson science teachers' individual and collaborative practice?

Working from these premises and this research question, I structured the workshop content to include a discussion of what scientific habits of mind are and strategies for fostering scientific thinking, developing science content vocabulary, implementing design challenges, and using quality real-time data and other web resources. Each of the strategies taught, demonstrated, and facilitated directly related to fostering scientific habits of mind. The second workshop day consisted of a review of what we meant by scientific habits of mind, and the strategies that were previously taught. In addition, each strategy, once reviewed, became the catalyst for small mixed grade-level group discussions about other strategies used by teacher participants that they found were successful or would like to try in fostering scientific habits of mind in their students, and about how fostering scientific habits of mind may look similar or different across the grade levels.

Methodology

Setting

My professional development workshop and subsequent research took place in the Hockinson School District where I have taught since 2006. The Hockinson School District is located in Brush Prairie, Washington, a small, rural community a stone's throw from Vancouver, Washington and Portland, Oregon. The district is home to four schools: Hockinson Heights Primary School (K-2), Hockinson Heights Intermediate School (3-5), Hockinson Middle School (6-8), and Hockinson High School (9-12) serving approximately 1900 students. Each workshop meeting occurred during our vertical collaboration time set aside in our district, except for the Intermediate Day 1 Workshop which occurred after school. In the Hockinson School District, students have one-hour early release every Wednesday. This hour has been designated to be used for collaborative purposes: district and building goals, content and grade level team meetings, and vertical collaboration across the district.

Data Collection

Case Study Methodology

I used a variety of data sources to drive the content of the workshop and to examine my research question including surveys, personal communications, phone conversations, and field notes. The structure of my research takes the form of an illustrative case study; using this structure allows me to describe the dynamic evolution of this study by weaving together the data and the emerging stories that illustrate the impact of the workshop experience on Hockinson science teachers' personal views and professional practice.

Surveys

Invitations to participate in the workshop and complete a pre-workshop survey through Survey Monkey was extended to all teachers K-10 who teach science in the Hockinson School District. A large percentage responded to the initial survey (57.7%) and, consequently, participated in the 2-day workshop (68.9%). Of those who participated in the workshop, 84%

completed the survey. The survey consisted of open-ended questions and Likert questions. The purpose of using Likert-type questions was to establish demographics including grade band, years of teaching experience within that grade band, and time spent teaching STEM-related content in the classroom. The open-ended questions were chosen to allow teacher participants to describe their understanding and experience integrating science, technology, engineering and mathematics (STEM) content, their comfortable level with finding and using real-time data and other quality web resources, and to illustrate what integrating STEM content or real-time data looks like in their classrooms. Using a mixed methods approach allowed me to knit together measurable data with emerging themes from the qualitative data.

Personal Communications

Personal communication was one of two primary sources of qualitative data. Throughout the course of developing, conducting and debriefing the workshop experience, personal communication from participants in the form of e-mails has provided feedback and collaboration, reflecting on theories of learning and professional best practices.

Phone **Interview**

The other primary source of qualitative data came from a rich phone interview with a teacher participant (R. Fern, personal communication, April 22, 2011). My colleague has 31 years of teaching experience in the Hockinson School District, primarily at the elementary level, and describes herself as, "the non-science person of the world." Using this method allowed me to probe in depth the concerns of science teaching, the needs of quality science learning, and the personal and professional impact of this workshop on her practice.

Field Notes

Field notes supplement the other sources of data; after each workshop presentation with each grade band and after every peer debriefing and member checking, I reflected on the events, conversations and new ideas or issues that emerged. Field notes throughout the study provided insight to how I interpreted survey data, feedback, personal communications, and then modified and adjusted the content of the workshop.

Data Analysis

I incorporated many methods to analyze my data over many weeks. Prior to meeting with each grade band, I filtered their responses on the survey by grade band and downloaded the data from Survey Monkey. I coded their responses looking for common concerns, issues, and themes. After the first day of the workshop with each grade band, I recorded my field notes including reflections, important points to include or exclude from the next presentation, and comments from participants. As I received e-mails during the month in between the two workshop days, I coded them again looking for concerns and themes. Prior to the second workshop day, I reviewed the unfiltered responses from the Survey Monkey as this meeting included all teacher participants. After the meeting, I again recorded my field notes focusing on comments, feedback, and my thinking about our science collaborative "next steps". My study culminated with a rigorous review and analysis of all the data I had collected. I first made a table outlining the survey data, including the questions, the results and comments, and emerging themes. Then I made a table of all personal communications, the phone interview and field notes, including what was written or said, the source of the data, comments, and emerging themes. In addition, I made a flow chart that described the evolution of my original research question to my present one which included the major events and conversations that perpetuated the shift. Finally, I triangulated my data by creating a theme matrix which included the emerging themes and the data sources.

Findings

Quantitative Data

Demographics.

Of the 33 participants (31 teachers and 2 administrators), 26 teachers completed the initial survey given prior to the first workshop day at a rate of 84% (administrators were not sent the survey). Those who participated represented 68.9% of the teachers in the Hockinson School District who teach science in kindergarten to tenth grade. Of those who participated in the survey, 46.2% of the respondents reported teaching in the kindergarten to second grade band, 30.8% reported teaching in the third to fifth grand band, 15.4% reported teaching in the sixth to eighth grade band, and 7.7% reported teaching in the ninth to tenth grade band (see Figure 1). In response to how long teacher participants have taught in their grade band, 26.9% reported teaching between 1 and 5 years, 26.9% reported teaching between 6 and 10 years, 11.5% reported teaching between 11 and 15 years, and 34.6% reported teaching 16 years or more (see Figure 2). When asked how much time teacher participants spend teaching STEM-related curriculum in the classroom each week, 15.4% of respondents reported that they do not teach STEM, 26.9% reported that they spend less than one hour, 19.2% reported that they spent one to two hours, 11.5% reported that they spent two to four hours, 26.9% reported spending five hours or more (see Figure 3). In looking at this question broken down into grade band responses, respondents teaching kindergarten through second grade reported that 25% did not teach STEM-related content, 58.3% taught two hours or less a week, and 16.7% reported teaching between two and four hours (see Figure 4). Respondents teaching in the third through fifth grade band reported that 12.5% do not teach STEM, 62.5% teach two hours or less per week, and 25% teach five hours or more (see Figure 5). Respondents teaching in the sixth through eighth grade band reported that 25% teach two to four hours and 75% teach five hours or more (see Figure 6). Two teachers participated at the ninth to tenth grade level and reported that they spent five hours or more each week teaching STEM-related content.

Qualitative Data

Qualitative data sources included personal communications, field notes, and a phone interview. Two major themes emerged from these qualitative sources: fostering scientific habits of mind is important and collaboration across grade bands.

Theme 1: Fostering scientific habits of mind is important.

One common theme that emerged from teacher participant comments, conversations, and personal communications is that fostering scientific habits of mind is important and should be integrated into existing teaching structures across content and grade levels. In my field notes prior to the first meeting with teachers across the district, I wrote, "Do they (students) see themselves as part of this vision? They engage in scientific practices everyday—asking questions, making predictions, analyzing and making decisions using data, etc." In an e-mail (R. Fern, personal communication, March 17, 2011), a teacher participant echoed my thinking when she wrote, "I definitely agree that we need to help our students see themselves as scientists and engineers and encourage them to think and do more problem solving." Another participant (D.

Chicks, personal communication, March 16, 2011) reported after our first meeting together, "I came away with a new appreciation for science and some great ideas I can use immediately in the classroom across all content areas. In fact, I plan to use one of your ideas for my observation next week." C. Anders (personal communication, April 21, 2011) an administrator who participated in the two-day workshop described in an e-mail how the idea of fostering scientific habits of mind was evident in students' learning experiences. She wrote, "I was walking around campus this morning and observed a class on a nature observation walk...each child had their own clipboard to record their observations. I haven't seen this before so I think it was a direct link to your work with us!"

Theme 2: Collaboration across grade bands.

Another theme that emerged from the qualitative data sources was collaboration across grade bands. The workshop presented the opportunity for teacher participants to collaborate within grade bands on the first day and to collaborate across the district on the second. After our second meeting, I received an e-mail from an administrator participant (C. Anders, personal communication, April 21, 2011) who wrote, "The group I was in had very meaningful conversations about the similarities in how kids learn across the grades. [A teacher] from the high school mentioned that she would like more game ideas. I told her that I had purchased a book at the last Marzano conference on games using vocabulary words across the disciplines. While it has some ideas for younger students, it is really geared for older kids. I am sending it up to her to use." A teacher participant called and asked if we could talk about her experiences resulting from her participation in the two-day workshop. In our conversation, she expressed (R. Fern, personal communication, April 22, 2011), "Any time we can talk to each other and hear what other grade levels are doing is great." Collaboration among participants was not limited to the workshop alone as participants reported conversations and discussions they have had with colleagues since our meetings together. Administrator, C. Anders wrote in an e-mail (C. Anders, personal communication, March 21, 2011), "I was able to have a discussion with a teacher on how they could support scientific inquiry when a student talked about what they learned about penguins while watching a u-tube movie at home." Teacher participant, R. Fern, summarized a conversation that occurred during her lunch the day after the workshop. She stated that her colleague had said, "You know it was so great to sit around and talk about what we were doing and no one said anything about the state standards." She went on to describe the conversation that had followed and finished up her thought with, "Isn't that great that we talked about how we can make science relevant for the kids and make them excited about it" (personal communication, April 22, 2011)!

Limitations

The ability to attend a workshop such as this one is one possible limitation. Although 68.9% of the science teachers in the Hockinson School District attended the K-10 vertical science collaborative meeting, this was possible because of the time for collaboration our district has built-in to the calendar. In fact, there was 100% attendance of the primary teaching staff at this meeting and a similarly high rate of attendance at their individual meeting. Since some districts do not have collaboration time that exists within contract hours, similar responses elsewhere may be limited by attendance.

Limitations of the data collection process included a small representative number of middle school and high school teachers who participated in this study; in a small district like ours, secondary science teachers make up a small percentage of the districtwide staff. Whereas the focus of this workshop was to connect Hockinson science teachers to effective strategies that foster scientific habits of mind, future study may include examining the impact of integrating these strategies into the classroom. Future data collection may include asking teachers to provide examples of modified lesson plans that illustrate fostering scientific habits of mind and samples of student work as a result of such implementation. Doing so, will provide valuable data as to the impact of modifying teaching strategies that foster scientific habits of mind on student learning.

Discussion and Implications For Study

The evolution of my study began with the first results of the pre-workshop survey. I noticed first that a much larger number of primary teachers and intermediate teachers had responded to the survey. From their responses, I realized that I was going to be working with a large number of very experienced teachers within their grade band. I also realized that many teachers reported either not teaching STEM related content in their classroom or taught less than two hours a week of it. About the time I was reviewing this initial data, the primary principal called me to get more information about my workshop presentation. We had a very honest conversation about the relevancy of my plan for her teachers. That conversation, along with the data from the survey, caused me to take pause and re-evaluate what kind of experience I wanted to facilitate for my colleagues. It was then that I called on my fellow Endeavor elementary school teachers to share with me the kinds of ideas and strategies that were grounded in their Endeavor experience and how they were implementing them into the classroom. From those threaded discussions, I decided to shift my focus to fostering scientific habits of mind, an important science concept that is accessible to everyone because essentially they are practices that we engage in whether we are in a science-related field or not. Rallying around this one idea would allow the workshop to be tailored to the specific needs of each grade band but would also provide a common topic that could be discussed and collaborated together in our vertical meeting.

Within the workshop and from personal communications, it became clear that once teacher participants had a common understanding of what scientific habits of mind were, they readily agreed that they were important to developing well-rounded, informed science students. I happened to have a conversation (R. Fern, personal communication, April 22, 2011) with the teacher who took her students on the nature walk around the school that was reported in the e-mail from one of the administrator participants. This fifth grade, 31-year veteran teacher, who did not consider herself a science person before, was so excited now to watch her students observe, experience, and learn. She told me that her worldview was opening up and that she wanted that for her students as well. As noted earlier, the participants too thought that developing scientific thinking in their students was something that could be done across content areas and grade levels. Furthermore, from the strategies that I presented, many perceived that the strategies themselves were relatively easy to implement and, consequently, fostering scientific habits of mind would not require anything more of them but intentional fine-tuning.

An unexpected outcome (theme) from this workshop project and study was the fostering of and benefits from district-wide science collaboration. The workshop started from a familiar point of grade band collaboration, common to our school district. At the primary level, I was able to tailor the workshop to accommodate their need for vocabulary development and active games that foster scientific thinking integrated into their existing literacy and mathematics focused-curriculum. At the intermediate level, the focus of fostering scientific habits of mind stayed the same; however, the strategies I demonstrated and facilitated changed to highlight design challenges and quality web resources. At the combined grades 6-10 meeting, the strategies slightly shifted again to accommodate the need for quality on-line resources. When all the groups came together in the combined vertical meeting, teacher participants reported that they appreciated being able to understand what fostering scientific habits of mind looks like at the different grade levels. A second grade teacher commented that she had never sat down and collaborated with a high school teacher and that they had both gained something from that collaboration. As reported previously, teacher and administrator participant comments during the workshop, in personal communications, and around the staff lunchroom table showed an appreciation for the opportunity to share their common and diverse experiences and a desire to keep the conversation going.

While the focus of this study shifted over the course of the workshop project, the goal "to broaden the concept teachers ha[ve] of themselves as science teachers and provide the necessary confidence to lead students through similar research projects" (Dresner & Worley, 2006, p. 2) remained the same. Teacher-led teacher in-service can be an effective means of professional development, but the time to prepare in-service workshops makes it difficult to have them often. Implications for future studies may include workshop models that are collaboratively designed and implemented; for example, teachers collaborate to determine a series of topics for collaboration and all participants bring their best practices to share. In addition, further studies as to the long-term impact of teacher-led in-service meetings would be beneficial. Furthermore, reflective case studies detailing the impact on student learning from implementing various strategies that foster scientific habits of mind would add legitimacy to the virtue of valuing and privileging scientific thinking and accompanying process skills in the K-10 classroom.

Conclusion

This project began as an opportunity to share my NASA Endeavor experience by providing real-time data and NASA web resources to my colleagues in the Hockinson School District. The outcome of this workshop project and study was so much more. With a shift in focus to fostering scientific habits of mind across curricula and grade levels, a common experience allowed teacher participants to share their diverse ideas and experiences. This sharing across grade levels reminded us of the benefits of collaboration and ignited a shared desire by many to continue the forging of relationships across the district and to figure out how to keep the conversation flowing, given our many responsibilities. Renee Fern (personal communication, April 22, 2011), a fifth grade teacher in the Hockinson School District, remarked to me in regards to teaching children that, “You got to strive to keep it fresh. You got to strive to keep it engaging.” I would submit that quality discourse and collaboration opportunities amongst teachers much also be fresh and engaging to be on-going, self-sustaining, and beneficial to the students whom we serve.

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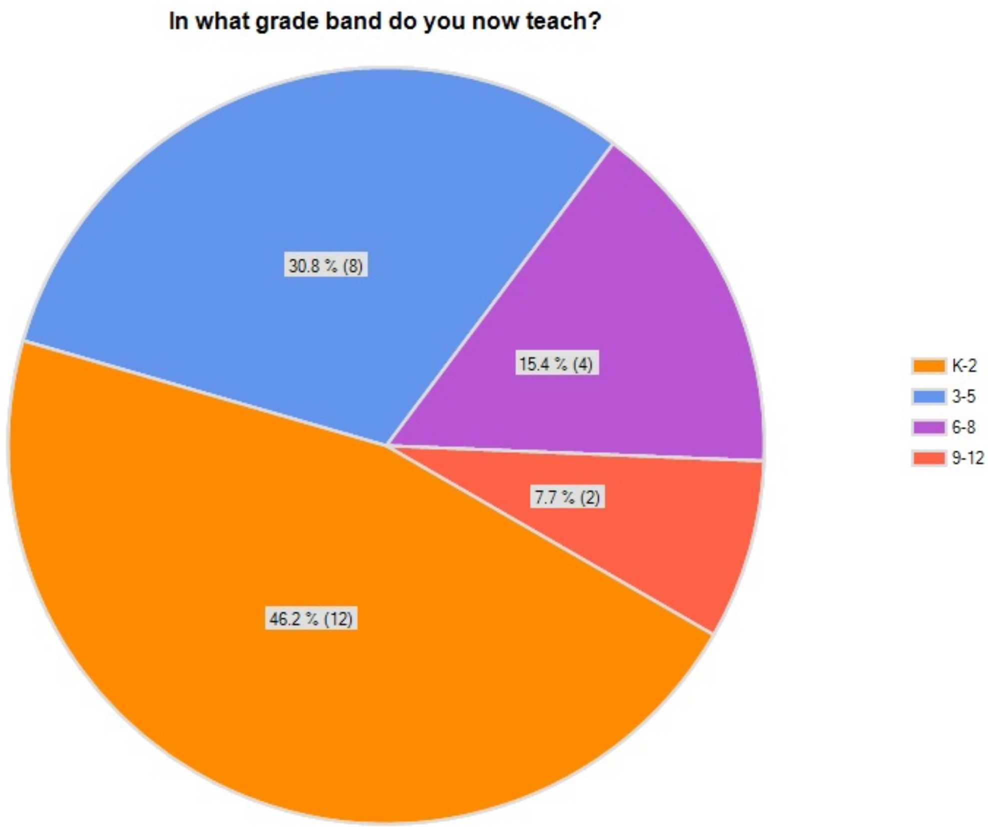

Figure 1. Pie chart of teacher grade band demographics

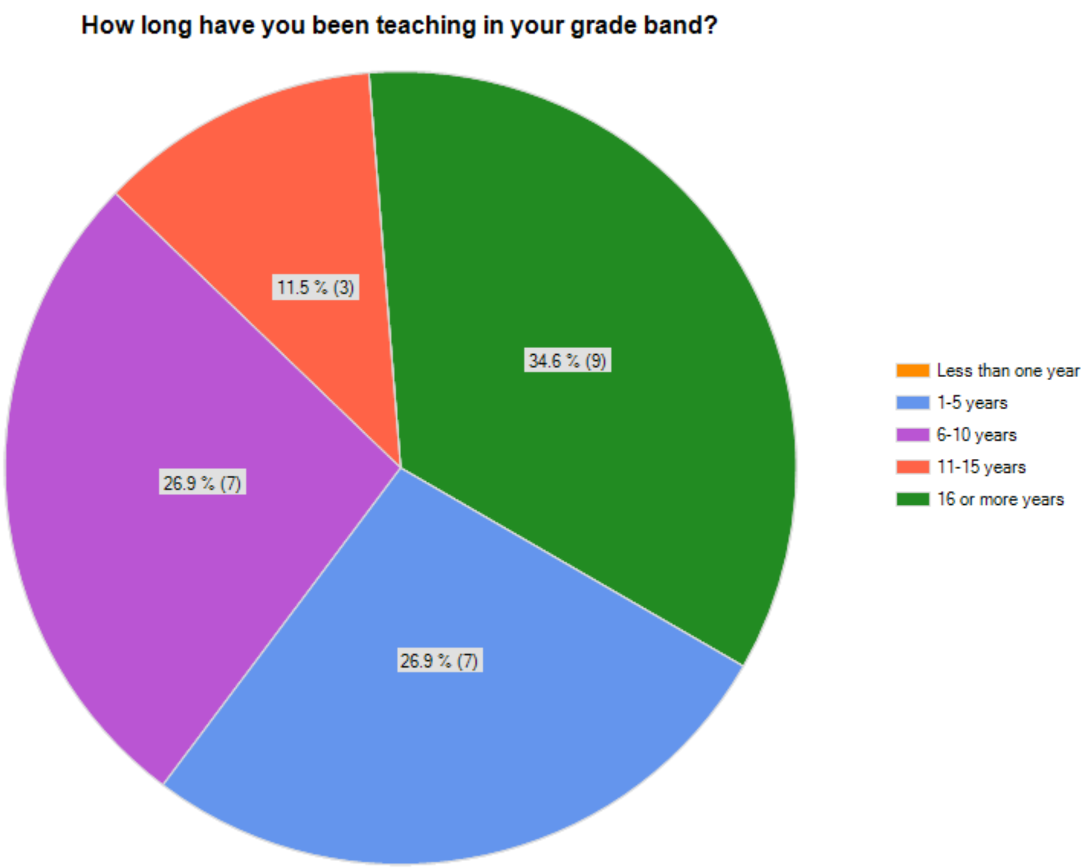

Figure 2. Pie chart of teacher years of service per grade band

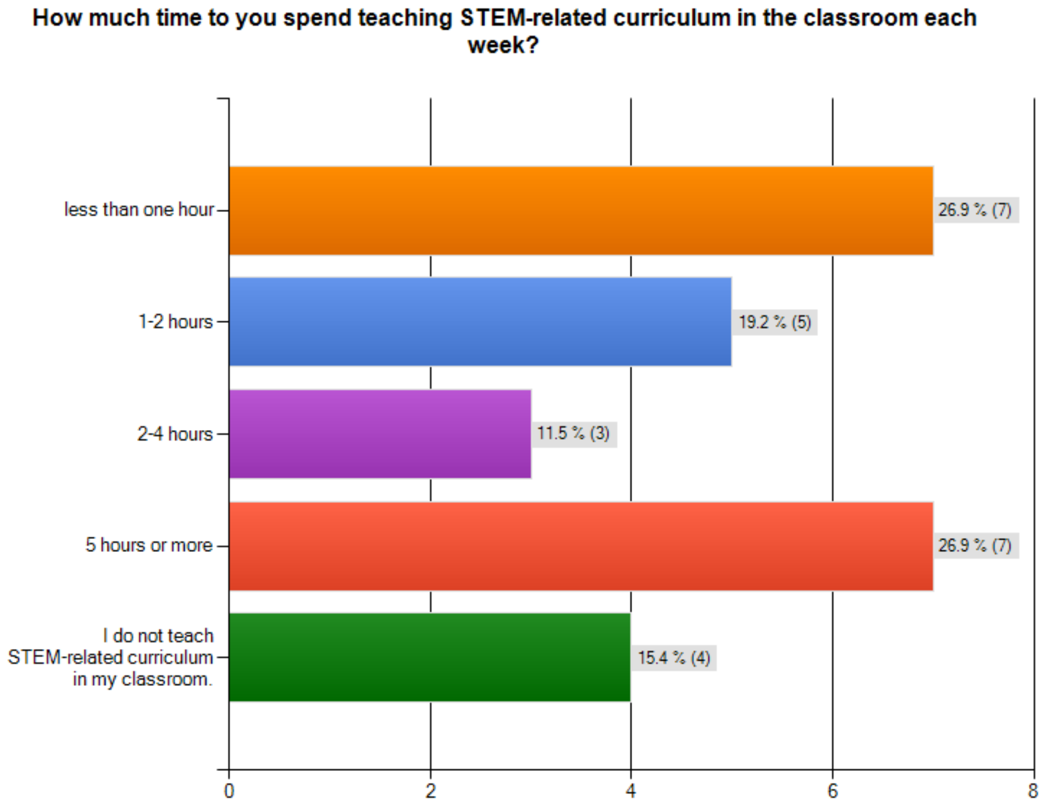

Figure 3. Graph illustrating how much time is spent per week on STEM-related curriculum.

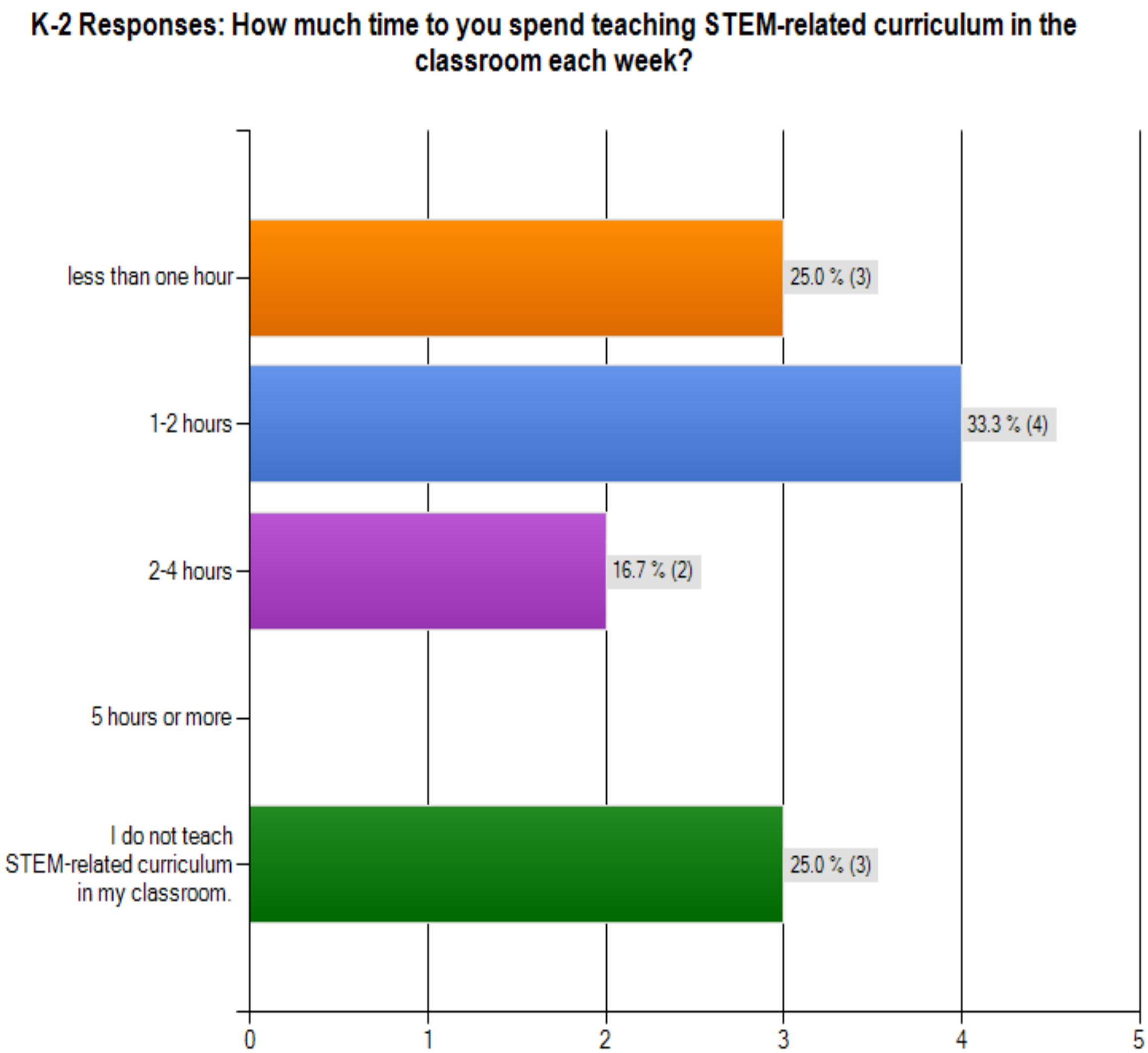

Figure 4. Graph illustrating how much time is spent per week on STEM-related curriculum for K-2 teachers.

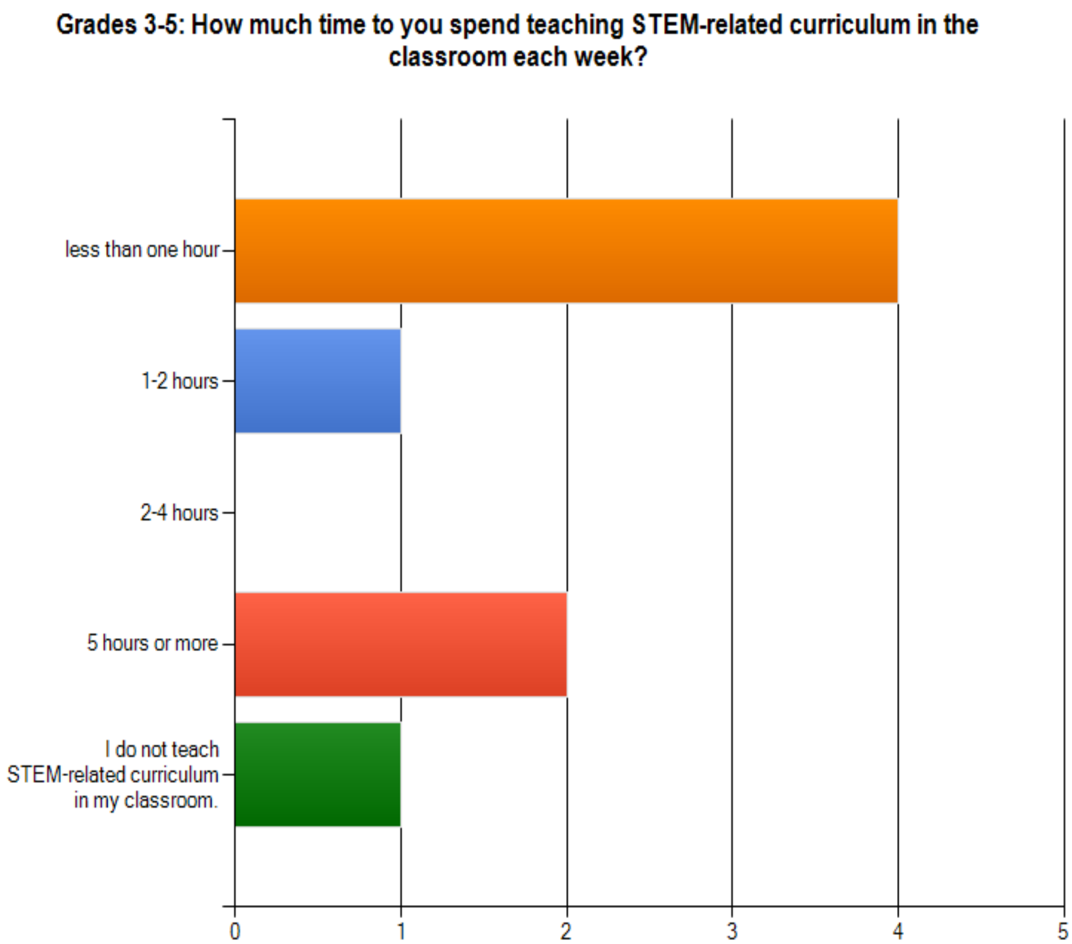

Figure 5. Graph illustrating how much time is spent per week on STEM-related curriculum for 3-5 teachers.

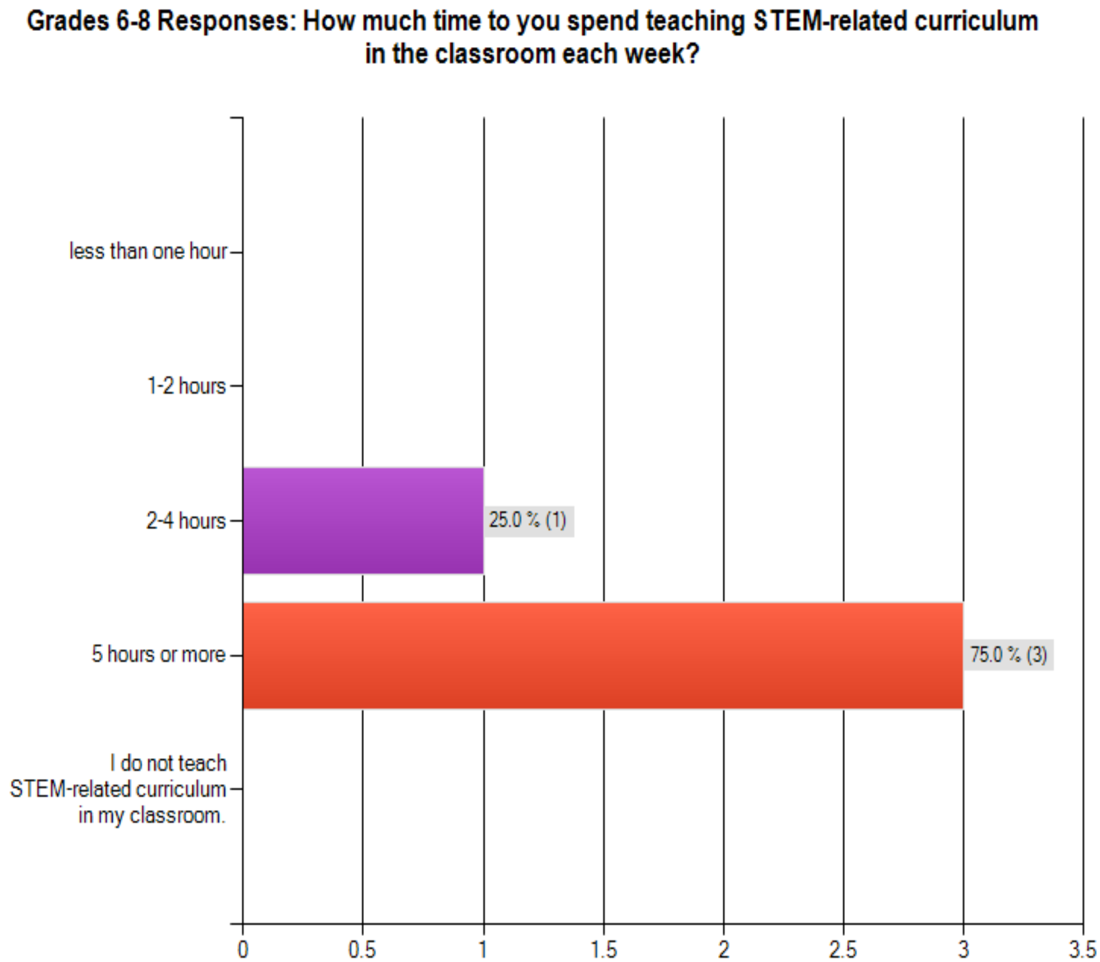

Figure 6. Graph illustrating how much time is spent per week on STEM-related curriculum for 6-8 teachers.