

## Case Studies of SJS Educators

### *Forging New STEM Education Pathways Across In-School and Out-of-School Setting*

Gary is a high school science teacher and manages the planetarium that is connected to the school. The planetarium serves the greater school system community in a suburban Midwestern community. In interviews, Gary describes how he was able to leverage this connection as the high school astronomy club advisor to engage up to 18 students in SJS during their lunch break and/or after school over the course of two years. During the first year, Gary met with students split between two lunch periods, and students worked at their own pace through the SJS explorations after school. Sometimes students would skip to go hang out with their friends, or they would have other commitments after school. Gary found that taking advantage of the one day per week when the school closes early, and the fact that the school's yearbook committee requested SJS images, helped motivate his students, but they did not go beyond the initial SJS Explorations to create investigations of their own. Gary modified his approach for the second year, where he worked with 4 students to conduct a more "in-depth" investigation. Also, the lunch meetings were condensed to one period, which seems to help attendance and conversation: "the atmosphere is better now, like, 'let's get down to business.'"

Field notes and emails indicate that Gary's idea to take a more structured, "in depth," inquiry-based approach for his second year working with students was inspired by his deeper engagement with the SJS staff and astronomers after he was invited to one of the in-person SJS PD workshops to help train the next cohort of leaders. With this additional exposure to SJS staff and astronomers, Gary became curious and inspired by the potential of the "uncharted territory" of the radio telescope to investigate the Milky Way. Though Gary had strong TPACK skills, he relied heavily on the support of the SJS staff and radio astronomers through email and the SJS forum. He discussed the "aha!" moments of the students as they "wrestled with their data" to "investigate anomalies," and how rewarding these "cool moments" were for him personally to witness their "great thinking," – "I am so proud of their tenacity. You should have seen their faces...they were so excited!"

During an interview, Gary described how this experience caused him to reflect and modify his pedagogy-- next time he would let the students wrestle with it a little longer before he intervened, and just prompt them with questions and puzzles. Since the radio astronomy content and technology was new to him, he plans to draw on his own experience asking the SJS staff and astronomers questions to scaffold students' experiences. When asked how important his astronomy background was in facilitating the students' learning, Gary acknowledges that it helped: "having more background knowledge allows you to ask better questions, lead down better paths to success with less dead ends," but that said, he believes that anyone with the curiosity and desire to learn can facilitate SJS and lead a group, they would just be co-learners. In other words, Gary also speaks to the importance of both TPACK *and* leaders' drive and enthusiasm. Gary's case study of pushing into "uncharted territory" also illustrates the benefits of sustained engagement from program staff and scientists. Building on Gary's enthusiasm, SJS staff asked Gary to create an SJS exploration around this topic so that others could benefit from his experiences leading youth through this inquiry-based investigations of the Milky Way. This celebrated Gary's agency and creativity, and it created a feedback loop for program development and sustainability.

*Jacob* is a dentist retiree who is very active in his local, relatively affluent, suburban community through his amateur astronomy club and volunteer position at a nature center. Jacob described in interviews and during in-person field visits how hard he worked to partner with local schools to offer SJS to youth. He initially “went to the head of science education and had a meeting about how ... [there are] a lot of people like me who are either close to retiring, or who are retired, with professional backgrounds, that could be adding a lot of value to the school system here.” Jacob goes on to describe the push back he received: “The school system is so concerned about litigation. We’re not being allowed in the schools. And this woman at the table [said], ‘Oh, the teachers with the Next Generation, everybody is so busy, everybody is stretched so thinly.’” Jacob notes that “I’m not alone... I’ve heard other people where they have gone, ‘I’ve been trying to get in to do my program, you know, in civil air patrol. I’ve been trying to do this for five years, and the schools won’t let me in.’” But Jacob remained persistent:

[Jacob] So, I turned around, I walked into school, and I met a teacher. I said, “Are you interested in this?” I went from the ground up, and that’s how I met Mrs. [teacher name]. [She said], “Oh, this sounds like a cool idea. Let’s go talk to the principal.”  
[Interviewer] So, you literally just walked into the school and asked? What did you do?  
[Jacob] Actually, I walked in the first time and they wouldn’t let me in the school. And then I asked a friend of mine from my [nature center] children’s club who is a teacher. I said, “Do you know a middle school teacher?” She said, “Well, how about somebody at [school name]. That’s right around the corner.” I said, “Fine.” She then looked up who the GT Resource Teacher was and she gave me Mrs. [teacher]’s name. I emailed her and told her about SJS. She said, “that sounds interesting,” and then I made an appointment and went in and talked to her. And I showed her the [SJS] framework. She says, “I think this would be a great, what they call, ‘CEU.’ Let’s go talk to the principal right now.”  
So... I went in from the ground up, rather than trying to go through administration down.

With the help of the Gifted and Talented (GT) teacher, Jacob was able to offer SJS as a Curriculum Enhancement Unit (CEU) that GT students could miss class to attend once a week (pending adequate performance). During the first semester, Jacob worked with 8-10 middle school students during the CEU period and a subset of 1-3 students who were able to consistently meet at the local library twice per week. Although, Jacob continued to encounter hurdles in merging in-school with out-of-school learning, such as the time constraints and student availability: Jacob notes that, “at the library, you could go as late as you wanted, but we would only get one or two students at a time.” During the second semester, Jacob implemented an application process and moved the after school sessions to the school. While “everyone has to clear out of school at three thirty, [the benefit is that] here [at school], if they’re available, they’re coming after school.” This illustrates the unique challenges of merging in-school with out-of-school learning, as well as the importance of Jacob’s agency and creativity in overcoming these challenges to lead to greater student participation.

In the context of time, school, and student constraints, Jacob struggled with pedagogical strategies. Through the SJS professional development, his own independent reading, and his experience working with students, Jacob grappled with his educational philosophy and profoundly restructured his pedagogy. In an interview he reflected on how his own traditional

education contrasts with the modern inquiry-based methods he learned at the SJS PD: “[Growing up], I was a spoon-fed learner... I would raise a hand, the teacher would give me the answer. I’d go, ‘okay, I got that data.’ [But at the PD training], I was like, ‘How do you do this?’ They [the SJS staff] would never me an answer. It was, ‘Well, what do you think? What tools did you use to try to find the answer?’ And I was, like, ‘Just give me the damn answer, you know, let me move on,’ so ... [the SJS staff] turned me into a new-age learner.” This emphasizes the importance of the TPACK framework for professional development, as informal educators can have a variety of skill sets and backgrounds. In Jacob’s case, his professional background and interest in astronomy allowed him to engage with the SJS content and technology tools (i.e. he could effectively resolve issues with the SJS resources and through communication on the discussion forum), but he had no formal training in pedagogy prior to SJS, making the PK element of the SJS PD model transformative for him.

*Chelsea* is a naturalist and partnered with a local school to offer SJS as an afterschool program for 8<sup>th</sup> graders in a rural town in the midwest. Like Jacob, she coordinated with the school’s Gifted and Talented teacher to recruit students. About eight students initially showed interest, then there were four committed students. Chelsea’s “Action Plan” outlined her idea to implement the same learning progression she experienced in the SJS PD for working with youth: “I really appreciated the format of this (PD) course where we were given some basic instructions, asked to investigate on our own, and return to a more specific follow-up.” During her retrospective interview, Chelsea describe how she had no astronomy background prior to the SJS training and felt that many astronomy topics were “out of my league,” but by going through the explorations she found that she could learn along the way. She says that “the professional development gave me the confidence to dabble and watch what happens.” The content in particular had an impact on Chelsea, “I’ve learned so much!” and now she shares what she learned “with whomever will listen.” In a follow up interview she described that “sometimes while the students are working their own thing,” she will “check out something of my own, some question I thought up,” and try it out with the SJS tools. She wants “to keep growing, to be prepared for if students hear something about, for example, that there is water on Mars ... how they might want to follow up with SJS.” This illustrates the impact of the experiential component of the SJS PD where educators learn at the intersection of content, technology, and pedagogy.

Chelsea consistently drew on the SJS PD TPACK experiences while working with youth, and used them to guide her pedagogy for motivating students -- when her students seemed frustrated she told them, “it’s okay. I didn’t know this stuff at first either.” While, before the PD training, she “had a general sense that using real instruments that astronomers use” would be important for engaging youth, this sense “was refined” when she learned of the new SJS feature of Telescope Time Request forms in one of the “Refresher” seminars. This feature allows youth to mimic the real-life disciplinary practice of astronomers to submit telescope time proposals. When Chelsea learned of this, she realized how SJS could reinforce the STEM education approach that she believes in, and this philosophy “really clicked.” She saw how inspiring this authentic practice was for youth: “they were honored to use the telescopes and couldn’t believe scientists would actually let them.” This illustrates the importance of integrating program features that support inquiry and engagement in authentic scientific practices.