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Abstract

The purpose of this study was to identify effective science teachers and analyze why they persist. This study was conducted using a mixed-methods approach including the Local Systemic Change Classroom Observation Protocol (LSC-COP) to generate a quantitative measure of science teaching effectiveness, along with using a phenomenological approach to investigate the experiences of effective science teachers who have stayed in the field. The median and mode of the LSC-COP capsule score were four and five respectively on a five-point scale indicating participants' instruction was likely to enhance students' understanding of science and their capacity to do science. Interviews with participants about their experiences yielded seven themes that pertain to effective science teachers' persistence: exemplary preservice/professional development programs, meaningful support, autonomy, student goals, engaging in deliberate practice, building relationships with students, and viewing teaching as a moral act. Our study found that for teachers to persist, they have to view teaching as more than a job and have the support and the freedom to engage in deliberate practice in order to continually improve.

Research Questions

1. To what extent are participants effective science teachers?
2. Why do effective science teachers persist in the teaching profession?

Background

- Attracting and retaining teachers has been a long-standing problem in science.
- Nearly 50% of new science teachers leave the field in the first five years (Ingersoll & Smith, 2003; Podolsky et al., 2016).
- Common factors identified in research for why teachers leave include low quality of teacher preparation, poor working conditions, stress and burnout, limited professional opportunities, and low salaries (Geiger & Pivoarova, 2018; Ingersoll & May, 2012).
- A great deal of expertise and decision-making occurs "behind the curtain" of teaching (Darling-Hammond, 2006; Lortie, 1975; Munby et al., 2001).
- Teachers make hundreds of non-trivial teaching decisions each day (Berliner, 1987; Dewey, 1929, Gun, 2014) in a dynamic environment (Clough et al., 2009).
- Effective teachers use some form of a framework to guide decision making.

Methods

1. Observed two lessons for each participant.
2. Took field notes, collected artifacts including any student handouts, and evaluated teachers using the Local Systemic Change Classroom Observation Protocol (LSC-COP) (Banilower, 2005).
3. Scores were used as a guide to generate an overall capsule score (Table 1).
4. Conducted three semi-structured interviews focusing on experiences in the classroom, their thoughts on how and why they are effective teachers, to what extent various factors (e.g., educational background, school culture) influence their decision-making, and their pedagogical knowledge.
5. Interviews were transcribed and coded using significant statements.
6. Significant statements were grouped into tentative broader units or themes (Creswell, 2013).
7. Participants were asked more detailed questions that related to the broader themes to glean more information about their experiences in the second interview.

Table 1: The LSC-COP synthesized rating scales. (modified from Horizon Research, 2005)

Level 1: Ineffective Instruction. Little or no evidence of student thinking or engagement with important ideas of science. The lesson is characterized by either passive learning (e.g., lecture) or activity for activity's sake.

Level 2: Elements of Effective Instruction. Instruction contains some elements of effective practice, but there are substantial problems. Overall, the lesson is significantly limited in its likelihood to enhance students' understanding of the discipline or capacity to successfully do science.

Level 3 Low: Beginning Stages of Effective Instruction. The instruction is purposeful and has a few elements of effective practice. Overall, the lesson is limited in its likelihood to enhance students' understanding of the discipline or capacity to successfully do science.

Level 3 Medium: Beginning Stages of Effective Instruction. Instruction is purposeful and characterized by quite a few elements of effective practice. Overall, the lesson is moderately limited in its likelihood to enhance students' understanding of the discipline or capacity to successfully do science.

Level 3 High: Beginning Stages of Effective Instruction. Instruction is purposeful and characterized by a number of elements of effective practice. Overall, the lesson is somewhat limited in its likelihood to enhance students' understanding of the discipline or capacity to successfully do science.

Level 4: Accomplished, Effective Instruction. Instruction is purposeful and engaging for most students most of the time. Some small issues may be present in the lesson; however, the lesson is reflective of reforms-based teaching.

Level 5: Exemplary Instruction. Instruction is purposeful and all students are highly engaged most or all of the time in meaningful work. The lesson is highly reflective of reform-based teaching.

Results

Table 2: Local Systemic Change Classroom Observation Scores

Pseudonym	Observation	Design	Implementation	Content	Classroom Culture	Capsule Score
Brianna	1	5	5	5	5	5
	2	5	5	5	5	5
Hannah	1	4	4	4	4	4
Ellie	1	4	5	5	4	5
	2	5	5	5	5	5
Ryan	1	5	5	5	5	5
	2	5	4	4	4	4
Payton	1	3	3	4	4	3H
	2	3	3	4	4	3H
Katie	1	4	5	5	5	5
	2	4	5	5	5	5
Emilia	1	5	5	5	5	5
	2	4	4	5	4	4
Tim	1	4	4	5	5	5
	2	4	3	4	4	4
Damien	1	4	3	4	5	4
	2	3	4	4	4	4
Mason	1	5	4	5	4	4
	2	4	5	5	5	5
Kyle	1	4	3	4	5	4
	2	3	4	4	4	4
Shawn	1	4	4	4	4	4
	2	5	5	5	5	5

7 evident themes among participant interviews regarding why they stay effective and persist as science teachers

Pre-service. Participants noted that a strong preservice program was an essential element to how they became and persisted with effective science teaching practices. Impactful attributes participants noted were: 1) professors modeled teaching effectively, 2) professors effectively taught science pedagogy, 3) the practicum experiences were meaningful and included multiple teaching experiences where professors and cooperating teachers provided feedback, 4) throughout the experiences, participants engaged with a coherent framework that helped them develop a research-base for making decisions.

- *"[T]here's a lot really that has come from pre-services in terms of strategies or even like the way I structure lessons to align with how students learn, like going back to learning theory. [Students are working] in pods because I want to promote the goal of being collaborators and also social learning theory. We learn best by engaging with others, you know, bridging [students'] Zone of Proximal Development, all that comes from pre-service classes. " (Kyle).*

Support. For science teachers to remain effective, they need a support system from a variety of sources-- including colleagues and administrators. Many participants mentioned they would not be as effective as they are without the support to take risks, persist, and the reminders to keep their focus on what's best for their students.

- *"Look for a collaborative group, look for people that you can work with. [F]ind those relationships and don't work in isolation because I think that that's going to be what really produces that burnout if you're feeling like you're by yourself all the time and creating that all on your own, that can be really hard." (Payton).*

Autonomy. Given teachers make numerous non-trivial decisions each day, the freedom to be responsive to students is a crucial need expressed by participants. When teachers have trust from outside of the classroom, they can make necessary adjustments with confidence.

- *"[I]f we as teachers don't have choice to try new things and take some risks and go out on a limb and try things in a different way, or to be responsive to what we're seeing with our kids and to know we need to try something different because this is simply not working. I don't know what you do without that freedom" (Brianna).*

Goals. All participants mentioned they have goals for students. These goals, similar to 21st-century skills, included: critical thinking, collaboration, creativity, being respectful, and a deep understanding of scientific content.

- *"Communication skills, compassion for other people, participation in society, understanding really important science ideas that are fundamental to how society functions, and some of the biggest challenges facing us… Nature of science is a goal, nature of technology is a goal" (Ryan).*

Deliberate Practice. Participants often mentioned to promote student goals effectively, they had to engage in a variety of teaching practices and strategies. These include, but were not limited to, facilitating mentally engaging activities, scaffolding with open-ended questions, having a logical sequence to lessons, considering students' cognitive and emotional needs, managing time, and monitoring students' engagement. Modifying instruction in order to improve learning for students and to stay fresh was a common strategy that participants exploited to remain effective long-term.

- ***"**I'm always trying something different. I almost never teach the same lesson the same way… So I'm always trying to tweak it, or fine-tune it" (Damien).*

Relationships. Participants valued relationships in order to better understand students' learning and create a classroom community conducive to learning.Participants viewed teaching as a partnership or relationship. Not only do they care about students, but they are actively finding ways to show students they care.

- *"[M]y kids know very well, and there are many of them in this class too, that if I know something like a kid's in crisis or if there's something off, I will stop class and I will get everybody on something else… [b]ecause working so hard on relationships with kids, the content just follows for them. Like, they'll work for you. They'll learn it for you" (Emilia).*

Moral Act. Participants touched on the profound moral nature of teaching. Katie, Tim, and Ellie said specifically, "the passion of developing people… it just fascinates me", "it's a moral obligation", and "it's not just a job", respectively. The desire to fulfill students' needs is evident in all participants.

- *"I have three of my own children. As they begin to reach school age and have their own teachers, I am becoming very much aware of the position I have in kids' lives. Someone is doing my job as a teacher for my own children and I cannot express in words how grateful I am for those individuals. I want to be that teacher for someone else's kid. I am being trusted to care for and teach someone else's children in the same way that I trust another teacher to care for and teach my own child… I want students to know they are cared for and teaching science is my platform for showing them grace and compassion" (Ellie).*

Limitations

- Given this study was based on phenomenological research methods, while using convenience sampling, generalizing the findings of this study should be done with caution
- A majority of the participants went to exemplary preservice programs with a similar framework for teaching. Consequently, the findings may or may not apply to individuals with different preservice backgrounds.
- All participants teach in suburban or rural schools currently. These findings, therefore, may or may not apply to urban settings.
- We assume the classroom observations were an accurate representation of the participant's teaching practices and participants' interviews are an accurate representation of their experiences.

Discussion

- Effective science teachers need to believe teaching is more than just a job. The decision-making framework (Clough et al., 2009) provided a means for participants to incorporate morality into their teaching. As John Dewey (1909) associates moral growth with intellectual growth, so, too, do these teachers.
- Expressing student goals centered around life skills and building meaningful and caring relationships with students were a few ways participants blended intellectual and moral teaching into their science classrooms.
- For the participants in this study, connecting science teaching to a greater purpose began with their preservice programs. By attending either a preservice program or professional development that fundamentally shifted their view on education, participants received the education necessary to persist, even in the face of difficult working conditions. Participants repeatedly stated that without the practicum experience within their teacher education program they would not incorporate effective strategies, student-centered lessons, and learning theory.
- Previous research has made clear that support systems can help retain teachers (Mérida-López et al., 2020; Podolsky et al., 2016). However, this study found that the *nature* of the support system matters. Participants who had support systems with like-minded colleagues and an administration that empowers teacher decision-making and autonomy were much more likely to feel valued. Given meaningful support systems have been found to help science teachers remain effective and persist, these support systems were an important factor for participants to remain driven in difficult working conditions.
- Participants view science teaching as a vessel to touch and shape the future through promoting student goals centered around crucial life skills and building long-lasting and meaningful relationships with students.
- While all participants articulated a coherent purpose of science education, the source of this purpose varied across participants. Having a rationale for teaching, therefore, appears to be much more important than the personal and moral reasons that underpin that rationale.

Conclusions

- Given close to 50% of science teachers leave in the first five years (Ingersoll & Smith, 2003), studying why effective science teachers persist has a number of implications for stakeholders in schools and teacher education programs.
- Our study found that teacher autonomy is a crucial factor for effective science teacher persistence. Teachers often face institutional constraints (Wilcox, 2017; Brickhouse & Bodner, 1992) that impact teacher autonomy. Therefore, administrators, who often have some control over the constraints teachers face, can work to actively support and encourage their effective science teachers to engage in research-based practices and approach their teaching from a mindset of deliberate practice. When it comes to hiring new science teachers, administrators should strive to build a team of like-minded science teachers who are goal-driven.
- This study implicates, to maintain effectiveness, teachers may need to make a change in order to have the support they need. Actions to stay motivated and persist include, but are not limited to, associating with alternate colleagues or moving schools to receive proper administrative support.
- This study also suggests teachers must have a strong relationship to captivate student involvement. To connect with students, teachers may employ these strategies, learning student names as fast as possible, learning unique facts about each student, displaying students' work, asking about personal interests, and many others. Once this connection is established, students are more likely to engage and participate in effective science learning. Additionally, the teacher may now begin to strive for student goals as outlined in the paper. By using strong student relationships, and a decision-making framework (Clough et al., 2009), teachers have a mechanism for structuring instruction centered around the student goals.
- Teacher educators should engage preservice students in exploring the purposes of science teaching and develop a strong, personal rationale for science teaching (Herman et al., 2017). Our participants noted their methods professors modeled effective science instruction and effectively taught students how to enact pedagogical practices. Therefore, teacher educators should strive to model and teach in a way that aligns to research-based teaching practices. Teacher education programs should strive to place preservice teachers that are engaged in effective science teaching practices so preservice teachers have concrete experiences with how those practices look in the "real world".

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