

DISSERTATION

PLACE-BASED EDUCATION: HOW TEACHERS ARE INSPIRED BY AND AFFECTED
BY PLACE

Submitted by

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Graduate Degree Program in Ecology

In partial fulfillment of the requirements

For the Degree of Doctor of Philosophy

Colorado State University

Fort Collins, Colorado

Fall 2021

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ABSTRACT

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Reports of ecological disturbances - wildfires, loss of biodiversity, drought, contaminated drinking water, extreme temperatures - fill the news. People have to navigate and manage these challenges. To do so effectively, requires that people are environmentally literate (EL), demonstrating an understanding of the problems, so they are motivated to take action. The problem in the United States is that the levels of EL are estimated to be relatively low, despite concerted efforts, since the 1960's, to promote environmental education in both formal (e.g., school) and informal (after-school, community-based) settings. K-12 schools are one important place to examine EL. One intervention strategy to examine EL is through the focus on place-based education (PBE).

This dissertation focuses on the experiences of secondary science teachers and their connection to natural and social places as a mediating influence on their instructional choices and professional decisions to remain in education. The research was initially designed using a social ecological systems (SES) frame but ultimately the analysis was framed around social cognitive theory (SCT). SES views humans as a part of - not separate from - natural systems. SCT describes how a person's behavior is shaped by their personal (i.e. knowledge, attitudes, and expectations) and environmental (social and natural environment) attributes.

Chapter 3 examines northern Colorado middle school teachers' implementation of locally developed place-based education (PBE) curriculum. The curriculum was designed with the

intention of promoting students' environmentally positive behaviors. Camera traps were placed near schools and teachers (n = 12) were provided with photographic data of urban wildlife to use during ecology lessons. Through our grounded theory study, we found that teachers who perceived a curricular alignment and drew on curricular agency were willing to adopt and adapt the lessons for their classrooms. Those who did not implement the lessons either lacked curricular agency or perceived a misalignment of the PBE lessons and their school context.

Chapter 4 examines the factors keeping highly qualified science teachers in rural schools in northeastern Colorado. The U.S. is experiencing a critical shortage of science teachers, particularly in rural communities, in part as a result of teachers having to navigate multiple expectations and few resources. Teachers respond professionally by either staying, moving within, or leaving the rural school system. Their choices have economic and organizational implications for schools because schools lose institutional knowledge and financial resources as they recruit and train new teachers. This case study of rural science teachers (n = 9) was informed by both systems theory and integrated capital theory and was designed to identify what factors affect teachers' decisions to remain or leave the rural classroom. My deductive analysis of interviews used an adaptive capacity lens to describe vulnerabilities, adaptations, and resilience that teachers felt they faced in the education system. When rural teachers were able to navigate both professional and social vulnerabilities by capitalizing on places, people, and community knowledge, they were able to build professional resilience and remain in the rural school system.

Chapter 5 was designed in response to the global COVID-19 pandemic. Within the science teacher education research community, there was a mounting concern that the pandemic would exacerbate the already concerning issue of science and mathematics teacher shortages. As the pandemic began to disrupt school systems in March 2020, teachers were expected to, on very

short notice, modify their instructional approaches. We recruited science, technology, engineering, and mathematics teachers who were supported with National Science Foundation scholarships because of their high-quality academic record and commitment to working in high-needs school districts. Participants graduated from universities or colleges in the Mountain West or western region of the Midwest. Their professional experience ranged from 1-10 years.

Through a series of three surveys (n = 153) administered throughout 2020 and follow-up focus group interviews (n=42) in early 2021, I examined the perceptions and beliefs of teachers about the education system response to COVID-19. I found teachers perceived the system as being most concerned about continuing instructional delivery. The needs of teachers to continue functioning in the classroom was a low priority. Additionally, most teachers believed the actions taken by schools to be negative or neutral. Teachers were categorized by years of experience (preservice 0, novice 1-3, early career 4-5, and master 6+) to compare their perceptions of success and intentions to continue teaching. Prior to the pandemic perceptions of level success increased with years of experience, but during the pandemic all categories of teachers reported decreased success. The loss of feeling successful particularly among early career and master teachers equated to a loss of support for preservice and novice from those with experience. In spite of teachers' negative beliefs about the school response and perceived low levels of success, teachers intended to remain in the classroom short-term. Their intentions to remain long term decreased. Teachers described both internal (personal) and external (environmental) variables influencing their intentions. This study confirms teachers' fortitude to remain and thrive in the classroom while also demonstrating limits to their persistence.

While this dissertation began with the intent to examine teachers' inclusion of place in their respective curricula, the findings highlighted the importance of teacher agency. When

teachers have the agency to act based on past experiences to shape current and future work in the classroom, they are then able to connect to local people and places. These connections are critical components to increasing both student and teacher EL and motivating them to take pro-environmental actions. Furthermore, teachers' agency is shaped by their perceptions of the capital or resources within systems to which they have access.

ACKNOWLEDGEMENTS

This dissertation is the product of the many people in my community who nurtured my passion for learning. First and foremost, I want to recognize my advisor, Meena Balgopal, for the opportunity to think deeply about science education. As moms cheering on our children at a swim meet, she engaged in lively conversations about the current state of science education in our community. She is responsible for planting the seeds of critical thinking about teacher practices. Where I saw limits in myself, she saw opportunities for my growth. Every day she took the time to nurture my ideas so that they bloomed into this body of research. I give you my deepest gratitude.

Thank you to my committee for opening me up to new ideas and different viewpoints. Laura Sample McMeeking, you brought to me the perspectives of an analytical education researcher and asked thought provoking questions. Your contributions to my research are invaluable. Kathleen Galvin, thank you for the inspiration to examine education through a social ecological systems lens. You opened up new ways of viewing my past as an educator while providing an avenue for my future as a researcher. Kevin Crooks, I am lucky to have collaborated with you in your endeavors to bring urban ecology into classrooms. It is always exciting to see what shows up on wildlife cameras.

This was undoubtedly a team effort. A special thank you to Andrea Weinberg at Arizona State University who is an integral part of the CSU Noyce Research team. You helped navigate the waters of survey work and quantitative analysis. Thank you to Graham Peers and Shane Kanatous for inviting me to be part of the Marine Biology team and experiment with

instructional techniques in your classroom. Watching you both engage students with your knowledge and research was mesmerizing.

A special thank you to the members of the Science Education Research Group. I am honored to have shared space with you that fostered critical thinking and laughter. I am particularly grateful to Dani Lin Hunter for the many times we collaborated. I thank you for questioning my assumptions.

I also want to thank the numerous science teachers who invited me into their classrooms and shared their experiences with me. You showed me how you used the places around you - in your classroom and in your community - to inspire students to ask questions and engage in the process of science. I thank you for your candor. You are formidable.

The biggest thank you goes out to my partner, Lance, who supported me in magnificent ways. It is because of your encouragement and patience that I was able to finish. Life is infinitely better and more exciting with you.

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CHAPTER 1

INTRODUCTION

The number of extreme weather events is rapidly increasing as global temperature increases reach record highs (Sippel et al., 2020). Communities are having to manage unexpected floods, drought, massive forest fires, freezing temperatures, and record heat waves affecting the functions of daily life. These changes in climate are directly linked to anthropogenic actions (IPCC, 2021). This dissertation was inspired by a study of social ecological systems - a framework for framing how people are embedded within and affect natural systems and vice versa. It is imperative for humans to understand how people and natural systems interact with one another to prepare for and respond to future ecological perturbations.

Environmentally literate (EL) individuals understand and care about environmental systems, possess skills needed to assess and address environmental problems, and are committed to working toward a sustainable solution (Hollweg et al., 2011). The term literacy has been extended beyond its original usage of referring to the ability to read and write. EL encompasses knowledge, skills, and attitudes needed to solve environmental problems (McBride et al., 2013). EL is the foremost goal of the environmental education (EE) movement, which aims to ensure the longevity of natural systems. Throughout the 1960's and 1970's, EE was succinctly defined as preparing citizens who are knowledgeable about the biophysical environment and its problems, have an awareness of solutions, and are motivated to implement those solutions (Stapp et al., 1969; Harvey, 1977; Schneider, 1977). Widely recognized in the United States and internationally, the Tbilisi Declaration of 1977 set a solid foundation for EE. The stated

objectives of developing increased environmental awareness, knowledge, attitudes, skills, and participation for all people (UNESCO, 1977) support the overall goals of (1) fostering awareness of and concern for the interdependence of economic, social, political, and ecological factors in urban and rural areas, (2) providing all people with opportunities to acquire knowledge, skills, values, and attitudes to make a commitment to the environment, and (3) create patterns of new behavior toward the environment (Palmer, 2003). Ultimately, the Tbilisi Declaration pushed for a paradigm shift from people viewing the environment as simply available for human use and consumption to placing ourselves as a part of the environment. The intention of this shift in perspective was to reinforce the notion that sustained environmental behaviors will result in positive long-term environmental and social outcomes (Dresner et al., 2015).

More recently UNESCO's initiative of education for sustainable development calls for people to act responsibly toward each other and the environment through peaceful and sustainable means based on the understanding that today's actions have implications for the planet and humankind in the future (Rieckmann, 2017). In 2015, all United Nations Member States adopted the Sustainable Development Goals (SDGs) as a shared vision for a prosperous world. Since the 2015 summit, progress has been made toward meeting the goals, yet different countries and educators have adopted the SDGs in different ways and to different degrees. As the world population grows beyond 7 billion people, straining the limited natural resources to sustain life, there is a growing recognition that we need to change the way people think about the relationship between humans and the environment to move toward responsible actions that meet global resource challenges. UNESCO's SDGs place value on people as part of the environment and essential actors in the creation and maintenance of a sustainable world.

Despite the well-defined definition of EE for more than 50 years and strong support for

EE in schools, the level of EL in the United States is surprisingly low (Coyle, 2005). In 2005, The National Environmental Education and Training Foundation (Coyle, 2005) published a report titled “Environmental Literacy in America” that estimated only 2% of US adults had reached a high level of EL. The report stated that “what passes for environmental education in America is usually environmental information,” falling far short of EE goals. Jordan et al. (2009) provides a conceptual model of ecological literacy considering the connection between knowledge and self. In a world in which global climate temperatures are rapidly increasing resulting in extreme effects on local communities such as extended drought, flooding, and intense weather for which communities are unprepared, the outlook is bleak for designing solutions to the wicked ecological problems resulting from climate change when people lack knowledge and skills to take action. Additionally, the low number of recent EL studies is disconcerting.

A starting point for understanding the low EL rate in the U.S. is the K-12 education system. When studying EE, researchers focus on either students or teachers. This dissertation focuses on the experiences of the teacher. Teachers play a crucial and influential role in the lives of students as they help to shape students' critical thinking and attitudes about the world around them. Science teachers in particular are charged with academic standards specifically addressing the environment. The Next Generation Science Standards (NGSS) were written to provide a comprehensive guide to science education in the U.S. including standards on environmental education and climate change. Although the NGSS was designed as national standards, states independently determine their own standards. Currently, 20 states have adopted the NGSS and 24 states have developed their own standards based on the National Research Council's Framework for K-12 Science Education which provided the basis for the NGSS (NSTA, 2021).

Lin and Shi (2012) provide evidence connecting student driven investigations with fostering student awareness, concern, and pro-environmental behavior. To increase EL in students and address academic standards, teachers can employ different student-centered methodologies and strategies. Inquiry based teaching is widely used to have students ask questions and investigate environmental issues that are of high interest to them. Problem based learning presents students with a social science issue to investigate and present a possible solution. Lacking from these methodologies is a direct connection to local places and people with opportunities to engage in civic action. Place-based education (PBE) directly addresses these deficiencies.

Place-based Education

Place-based education (PBE) uses the local context as a starting point for creating opportunities for learning about the ecological and social wellbeing of the surrounding community and is, in part, a concerted effort to encourage civic engagement (Woodhouse and Knapp, 2000; Smith, 2002; Gruenewald, 2003b; Sobel, 2004). The aim of this progressive form of education is to ground learning in local phenomena that includes students' lived experiences and promote understanding of the interdependence between their lives and others in their community. Connections between people and the natural world are an important part of being human. Increasing engagement with and understanding of the local natural environment increases a person's connection to and sense of belonging in that place. Understanding and appreciating a local natural area includes not only knowing about the environment but also how the environment is tied to local social structures such as economics and politics. For example, one may have an appreciation for the ecology and biodiversity of a local open space grassland but also knowing how the open space may be involved in attracting tourism and recreation to the

area may play a role in a person's civic engagement associated with policies governing the grassland. Different communities have different local resources from which to draw learning experiences and actively engage students. To make use of local resources requires the engagement of and collaboration between schools and community organizations thereby developing numerous connections among community members (Nagel, 1996). Connecting the natural environment with community social structures supports the interdisciplinary nature of PBE (Gruenewald, 2003a)

The primary value of PBE is to strengthen a person's connection to the people and places in which an individual lives. Potential outcomes of the strengthened connection provides benefits to both people and natural places. People may experience (1) improved livelihoods, (2) a change in behaviors that favor conservation strategies, (3) increased civic engagement and participation in natural resource management processes, (4) positive change in local economics, or (5) increased pride in being a part of the local area. The environment may experience (1) recovery from previous ecosystem degradation, (2) increases in biodiversity of flora and fauna, or (3) sustainable use of ecosystem services. PBE outcomes help define divisions between theoretical claims about the aims of PBE. Smith and Gruenewald (2007) view PBE as a form of critical pedagogy offering opportunities to engage with issues of race, gender, class, and culture. Issues affecting natural area management do not affect all community members equally. Use of PBE as a critical pedagogy pushes teachers and students to consider these differences and critically examine how use of and changes to natural areas various community groups including themselves.

Relationship Between Place-based Education and Environmental Education

PBE encompasses the broader goals of environmental education (EE) making the teaching of environmental responsibility and taking action an essential feature of PBE (Sobel, 2004). Those who embrace this view (Gruenwald, 2003b; Knapp, 1985) believe that PBE embraces the teaching of inquiry skills, values clarification, and problem solving. Starting with examining one's impact on the local environment sets the groundwork for understanding one's responsibility to take action toward global sustainability (Gruenwald, 2003b). Not only do PBE and EE prepare students to be informed citizens, they prepare them to examine issues and make informed choices that have broader implications about the environment (Knapp, 1985, 2005). To investigate specific environmental issues and employ decision making skills and values to make environmentally conscious decisions considering one's relationship to natural systems is sometimes equated with the term "environmental literacy". According to Short (2009), EE is educating "for" the environment.

Proponents of PBE and EE believe a necessary curricular focus is to provide ongoing opportunities to interact with the environment (Louve, 2005). These experiences should begin in early childhood and continue throughout life. As a way to develop environmentally responsible behaviors, these experiences should be deliberately organized by schools, as well as community groups (Sobel, 2004). Service learning projects are an example of one such experience that can connect local issues with the development of understanding stewardship of the natural environment (Kraemer, Covitt, & Zint, 2002).

There are differences in perspectives around the issue of changing people's behaviors toward the environment and how this is best accomplished. On the one hand, some theorists contend that knowledge about the environment precedes any actions on behalf of the

environment (Orr, 1994) while others focus on the connection between changes in attitude influencing changes in behavior (Hungerford and Volk, 1990). Others promote individual choice as the primary factor in taking environmentally responsible actions (Heimlich & Androin, 2008) while some contend that the development of a sense of place through activities that create place meaning and place attachment (Kudryavtsev, Stedman, & Krasny, 2012) comes before behavior change. No matter the pathway, PBE and EE promote the goal of individuals taking action to support the responsible use and management of natural areas. Additionally, PBE and EE support inquiry teaching methods, value interdisciplinary instruction, community connections, and the development of transferable knowledge and skills to take part in maintaining the health of their community.

Although there are strong common components of PBE and EE, they do not hold uniform points of view. In EE, the natural world is the environment, whereas in PBE the natural world consists of the interactions of the environment with social and cultural conditions created by people. EE promotes broad goals from local to global improvement of environmental health while PBE puts its focus on local environmental and social health. PBE promotes a “sense of place” that is positioned to make a commitment to supporting the local community now and in the future. Additionally, PBE is better situated to integrate cultural funds of knowledge therefore it’s a strategy that complements inclusive science pedagogy (Gruenwald, 2003a).

As Smith and Gruenwald (2007) claim, the origins of PBE are grounded in a critical pedagogy to connect students learning about and taking action in local places (Gruenwald, 2003b). Since its inception, PBE has come into use across multiple academic contents but mainly in the context of studying a local place, person, or issue. PBE as an impetus for student action

has been sidelined. Therefore, there is a need to understand how teachers view PBE and their motivations for using PBE as it was originally visioned in their classroom.

Dissertation Organization

I began my graduate work with intentions to study environmental literacy. However, drawing on my previous 25 years as a K-12 educator and teacher educator, I also was drawn to studying the pervasive issue of the science teacher shortage. Working with my advisor, who has interests in both of these areas, my dissertation work bridges these two areas of study.

This dissertation's original focus was centered on examining *how* PBE was used in secondary science classrooms. Yet, the focus shifted in response to a student's question that I observed during a classroom visit in the early stages of data collection. During a middle school lesson on food pyramids involving grass, rabbits, snakes, and hawks, a student asked, "Where are people?" The teacher responded, "Don't worry about them" and continued the lesson. Reflecting on the fact that the teacher excluded people from the environment in her lesson on environmental systems made me wonder how common this was. Although all public school teachers are expected to adhere to national and state academic standards, their own values, perspectives, and beliefs shape how they teach. Indeed, others have also noted that our beliefs about social ecological systems and the roles that humans play affect how we determine whether environmental issues are concerns or not (Casper & Balgopal, 2018; Casper et al., 2021). Furthermore, our beliefs about the environment influence how we communicate these issues in classrooms (Casper & Balgopal, 2020). I observed similar instances in other classrooms. Acknowledging that teacher perceptions affect how they teach shifted my focus on examining *why* some teachers use place in their teaching and why others do not. Along with my advisor and our research team, I helped conceptualize a model about schools as systems with particular

attention placed on understanding how teachers respond to the system. The outcomes of these conversations was a conceptual paper published in *Advances in Development in Human Resources*, included in this dissertation as Chapter 2. The conceptual model blends social cognitive theory (explaining individual behavior) and adaptive capacity theory (explaining system resilience). Developing this model helped shape how I thought about teachers' use of place in the classroom and their place within the education system. My three empirical studies were informed by the development of this integrated model.

Chapter 3 presents the motivations of middle school science teachers to implement PBE to study urban wildlife around their school and in the broader community. This study was designed around my partnerships with Dr. Kevin Crooks, a Professor of Fish, Wildlife, and Conservation Biology, who has long encouraged teachers to collect authentic wildlife data captured from camera traps. Funding from the National Science Foundation (Grants #1540794 and #1413925) and Environmental Protection Agency (Environmental Education Grant # NE-96882001-0 on which I was a co-PI) provided funds to pay for wildlife camera traps for middle school teachers to place near their schools. These grants also provided incentive funds for teachers to participate in professional development around PBE curriculum. Alignment with the school context (e.g. standards, length of class, and administrative support) and teacher agency (i.e., their willingness to use new curricula) influenced the degree to which teachers were able to implement the curriculum. Implementers of PBE were able to adapt curriculum to the school structures that surround their work in the classroom. Additionally, they saw connections between the curriculum and personal interests from which they were able to draw resources for teaching. PBE implementers were able to move students from knowing about their local environment to

having students engage in civic actions about their environment (e.g. extended wildlife monitoring and public displays about urban wildlife).

The impact of science teacher attrition, particularly in rural schools, affects the quality of education, including environmental education, for rural students. As part of the National Science Foundation Noyce Program Coordinator (Grant #1540794), I worked with the CSU Noyce research team (Dr. Meena Balgopal, Professor of Biology and my doctoral advisor, Dr. Andrea Weinberg, Assistant Professor of Sustainability Education at Arizona State University, and Dr. Laura Sample McMeeking, Director of the CSU STEM Center) to design my study of rural teacher experiences. Chapter 4 examines factors that convince science teachers to remain in rural schools. Teacher's decisions to remain or leave their current classroom position are influenced by their thinking about the community in which the school is located and their thinking about personal, professional, and social contexts in which they perform their job. Rural science teachers who remain in their school long term are able to manage the challenges unique to rural schools draw on professional, social and environmental capital. They are able to integrate themselves and the content they teach into the people and places that make up the rural community.

The final study of this dissertation (Chapter 5) intended to examine how rural teachers use PBE to study urban wildlife. In other words, I had hoped to combine findings from chapters 3 and 4 in my final chapter. Unfortunately, I had to revise my plans. The global COVID-19 pandemic altered the context of teaching, so I could no longer study how teachers use local places in their curriculum. Being opportunistic, though, I modified my plans and examined how places (i.e. their school) affect teachers. Working with Noyce research team, we received National Science Foundation Supplemental Funding (Grant #2029302) to conduct this research.

Paper 3 examines teachers' perceptions of the education system response to the pandemic and the influences of the response on their intentions to remain in the education system. The pandemic changed how teachers were able to access the places and resources in which they were accustomed to teaching. For science teachers, this unexpected and dramatic disruption left them feeling unsuccessful at facilitating student learning. Although they expressed a commitment to remaining in education for the short term, long term commitment declined. Teachers described both internal (i.e., personal) and external (i.e., environmental) capacities as influencing their decisions to remain.

This dissertation uses place as a unifying theme to examine the experiences of teachers through multiple theoretical lenses and methodological approaches. The findings illuminate the role local places play in teaching about the environment and connecting teachers to the place in which they teach. When people develop a sense of place they are more likely to act in ways beneficial to the environment. As the climate continues to change, it is essential for everyone to understand how people and natural systems interact.

Literature Cited

- Casper, A. M. A., & Balgopal, M. M. (2018). Conceptual change in natural resource management students' ecological literacy. *Environmental Education Research*, 24(8), 1159-1176.
- Casper, A. M. A., & Balgopal, M. M. (2020). How guest experts tell stories about environmental socio-scientific issues in an undergraduate class. *International Journal of Science Education*, 42(9), 1568-1584.
- Casper, A. M. A., Fernández-Giménez, M. E., & Balgopal, M. M. (2021). A tool for measuring ecological literacy: coupled human-ecosystem interactions. *The Journal of Agricultural Education and Extension*, 27(1), 21-34.
- Coyle, K. (2005). Environmental literacy in America: What ten years of NEETF/Roper research and related studies say about environmental literacy in the US. *National Environmental Education & Training Foundation*.

- Dresner, M., Handelman, C., Braun, S., & Rollwagen-Bollens, G. (2015). Environmental identity, pro-environmental behaviors, and civic engagement of volunteer stewards in Portland area parks. *Environmental Education Research*, 21(7), 991-1010.
- Gruenewald, D. A. (2003a). Foundations of place: A multidisciplinary framework for place-conscious education. *American Educational Research Journal*, 40(3), 619-654.
- Gruenewald, D. A. (2003b). The best of both worlds: A critical pedagogy of place. *Educational Researcher*, 32(4), 3-12.
- Harvey, G. (1977). A conceptualization of environmental education. In J. Aldrich, A. Blackburn, and G. Abel (Eds.), *A report on the North American Regional Seminar on Environmental Education* (pp. 66–72). Columbus, OH: ERIC Clearinghouse for Science, Mathematics, and Environmental Education (ERIC Document Reproduction Service No. ED 143 505).
- Heimlich, J. E., & Ardoin, N. M. (2008). Understanding behavior to understand behavior change: A literature review. *Environmental Education Research*, 14(3), 215-237.
- Hollweg, K. S., Taylor, J. R., Bybee, R. W., Marcinkowski, T. J., McBeth, W. C., & Zoido, P. (2011). *Developing a framework for assessing environmental literacy*. Washington, DC: North American Association for Environmental Education.
- Hungerford, H. R., & Volk, T. L. (1990). Changing learner behavior through environmental education. *The Journal of Environmental Education*, 21(3), 8-21.
- IPCC. (2021). *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press. In Press.
- Jordan, R., Singer, F., Vaughan, J., & Berkowitz, A. (2009). What should every citizen know about ecology?. *Frontiers in Ecology and the Environment*, 7(9), 495-500.
- Knapp, C. E. (1985). *Using Valuing and Inquiry Skills in Environmental Education*. Retrieved from <http://www.eric.ed.gov/PDFS/ED263003.pdf>
- Kraemer, A., Covitt, B. and M. Zint. 2002. *Evaluation of Chesapeake Bay Foundation individual and combined middle school education programs*. Report to the Chesapeake Bay Foundation, Annapolis, MD.
- Kudryavtsev, A., Stedman, R. C., & Krasny, M. E. (2012). Sense of place in environmental education. *Environmental Education Research*, 18(2), 229-250.
- Lin, E., & Shi, Q. (2014). Exploring individual and school-related factors and environmental literacy: Comparing US and Canada using PISA 2006. *International Journal of Science and Mathematics Education*, 12(1), 73-97.

- Louv, R. (2005). *Last child in the woods: Saving our children from nature-deficit disorder*. Algonquin books.
- McBride, B. B., Brewer, C. A., Berkowitz, A. R., & Borrie, W. T. (2013). Environmental literacy, ecological literacy, ecoliteracy: What do we mean and how did we get here?. *Ecosphere*, 4(5), 1-20.
- Nagel, N. G. (1996). *Learning through Real-World Problem Solving: The Power of Integrative Teaching*. Corwin Press, Inc., 2455 Teller Road, Thousand Oaks, CA.
- National Science Teaching Association. (2021, October 14). *About the Next Generation Science Standards*. <https://ngss.nsta.org/about.aspx>.
- Orr, D. W. (1992). *Ecological literacy: Education and the transition to a postmodern world*. Suny Press.
- Rieckmann, M. (2017). *Education for sustainable development goals: Learning objectives*. UNESCO Publishing.
- Schneider, A. (1977). 1: The nature and philosophy of environmental education: Goals and objectives. In J. Aldrich & A. Blackburn (Eds.), *Trends in Environmental Education* (pp. 23–34). Paris: UNESCO.
- Short, P. C. (2009). Responsible environmental action: Its role and status in environmental education and environmental quality. *The Journal of Environmental Education*, 41(1), 7-21.
- Sippel, S., Meinshausen, N., Fischer, E. M., Székely, E., & Knutti, R. (2020). Climate change now detectable from any single day of weather at global scale. *Nature Climate Change*, 10(1), 35-41.
- Smith, G. A. (2002). Place-based education: Learning to be where we are. *Phi Delta Kappan*, 83(8), 584-594.
- Smith, G., & Gruenewald, D. (2007). *Place-based education in the global age: Local diversity*. NY: Routledge.
- Sobel, D. (2004). Place-based education: Connecting classroom and community. *Nature and Listening*, 4, 1-7.
- Stapp, W. B., Havlick, S., Bennett, D., Bryan, W., Fulton, J., MacGregor, J., et al. (1969). The concept of environmental education. *The Journal of Environmental Education*, 1(1), 30–31.
- UNESCO. (1977). *Trends in environmental education*. Paris: Author.
- Woodhouse, J. L., & Knapp, C. E. (2000). *Place-Based Curriculum and Instruction: Outdoor and Environmental Education Approaches*. ERIC Digest.

CHAPTER 2

DEVELOPING RESILIENT K-12 STEM TEACHERS¹

The foundation of American success is the guarantee of access to K-12 educational opportunities. Schools across the country are experiencing what's been termed a teacher shortage crisis, heavily influenced by both a reduction in teachers entering the workforce as well as startlingly high rates of teacher attrition. According to the National Center for Education Statistics, within the first five years of teaching in K-12 classrooms, there is a 17% attrition rate of teachers (Kaigher, 2011), although other models predict that the attrition rate is closer to 30% (Darling-Hammond, 2010; Ingersoll 2001). High quality teachers are in short-supply and are particularly difficult to retain in urban regions (Jacob, 2007) and rural communities (Ingersoll, 2003). Furthermore, for high-poverty schools, the teacher attrition problem is exacerbated (Hanushek, Kain, & Rivkin, 1999; Ingersoll, 2001; Ingersoll & May, 2011) and these schools have a notably hard time recruiting and retaining staff (Borman & Dowling, 2008).

For Science, Technology, Engineering, and Mathematics (STEM) teachers, shortages are even more pronounced. Vacancies in STEM classrooms are more prevalent than any other discipline (Cowan, Goldhaber, Hayes, & Theobald, 2016). In a meta-analysis, Borman and Dowling (2008) found that teacher attrition is more prevalent for those who teach mathematics and science, and because these subjects are required for graduation in all states, this a national issue. Therefore, recruiting and retaining STEM teachers prepared to teach across educational

¹ Published as Wright D. S., Balgopal, M. M., Sample McMeeking, L. B., & Weinberg, A. E. (2019). Developing Resilient K-12 STEM teachers. *Advances in Developing Human Resources*, 21(1), 16-34.

contexts (i.e., geographic, economic, cultural) is a significant and timely concern. Challenges with recruiting across educational contexts are exacerbated by the fact that teachers typically intend to teach in communities that are most like those in which they were raised (Boyd, Lankford, Loeb, & Wyckoff, 2005).

Some of the greatest teacher shortages are in high-poverty schools that often are in urban and rural communities (Ingersoll & May, 2011), and Abel and Sewall's (1999) research found that poor working conditions and classroom management can contribute to high levels of teacher stress and burnout. Some solutions to the issues of staffing schools across communities with STEM teachers focus on the recruitment and preparation of teachers for diverse school settings during their teacher education programs. Some headway has been made, for example, with recruiting. Other proposed solutions include professional development and structures of support for in-service teachers to help them increase their capacities to respond to workplace demands and disruptions (e.g., Gist, 2018).

There are implications for districts, schools, classrooms, and students when there is a teacher shortage. Teacher turnover costs school districts over \$2.2 billion per year (Haynes, 2014). Additionally, there are challenges of developing and maintaining long-term professional relationships between teachers and the communities they serve (Darling-Hammond, 2010). These challenges disproportionately affect high-poverty schools, which struggle with lower per-pupil budgets on top of having an average of 50% more teacher turnover each school year than affluent schools (Darling-Hammond, 2010). Varied student needs (e.g., English language acquisition, special education, and access to sufficient nutrition) place additional demands on teachers, who may not have had sufficient formal training to support these student needs (Lee, Maerten-Rivera, Penfield, LeRoy, & Secada, 2008; McLeskey & Billingsley, 2008).

Reasons for Teacher Attrition

While a decrease in enrollment of students into teacher education programs contributes to the teacher shortage (Hutchison, 2012), attrition is of utmost concern. Teachers leave schools or leave teaching altogether because of challenges they face in the classrooms and the systems within which they work (Borman & Dowling 2008; Darling-Hammond, 2010; Gist, 2018). Proportionally, very little of the attrition is due to retirement (Henke, Chen, & Geis, 2000). Instead, Darling-Hammond (2010) identified three major reasons for high teacher turnover: poor working conditions, lack of preparation, and lack of mentoring and support. Teachers in their early years of teaching have not accumulated enough knowledge and expertise of the profession and, therefore, have less to lose compared to those who have stayed in the profession longer (Guarino, Santibanez, & Daly, 2006; Kirby & Grissmer, 1991; Tait, 2008). Experienced teachers, who have spent many years within a career with a potentially high-impact but with myriad barriers to success, may burn out of the profession, much like employees in other, similar, sectors such as healthcare (e.g., Kilroy, Flood, Bosak, & Chênevert, 2017). The challenges facing teachers in general can be extrapolated to STEM teachers specifically. Although statistics are not specified for STEM content areas, the Learning Policy Institute recently reported shortages of science and mathematics in most states (Sutcher, Darling-Hammond, & Carver-Thomas, 2016).

Many demands (e.g., including meeting the needs of diverse students, adhering to new academic standards, demonstrating student growth on standardized assessments) are placed on teachers (Darling-Hammond & Bransford, 2007; Pitot, 2014; Woodbury & Gess-Newsome, 2002), especially for novice teachers, who are expected to perform the same roles as experienced teachers (Borman & Dowling, 2008). Of the teachers who remain in the profession, there is a

marked “shuffling” of job location from high-poverty schools to wealthier ones (Achinstein, Ogawa, Sexton, & Freitas, 2010; Showalter, Klein, Johnson, & Hartman, 2015). In fact, teachers in high-poverty schools leave at a rate double that of those in low-poverty schools (Darling-Hammond, 1997).

Little attention is paid to the professional struggles of individual teachers and how these experiences might influence professional resilience, which we define as having the capacity to respond to occupational turbulence in ways that allow them to remain in the profession. Some teacher advocates argue that teachers need financial incentives to remain in the profession. A higher salary, though, may not be enough of an incentive to retain the numbers of teachers needed to meet U.S. workforce demands (Ingersoll, 2002). Other teacher concerns include job satisfaction regarding administrative support, student motivation, and student discipline (Darling-Hammond, 2010; Ingersoll, Sirinides, & Dougherty, 2018). At an organizational level, schools and districts could move toward structures and policies that promote number of high-involvement work practices (HIWP), which have been shown to improve employee well-being (Boxall & Macky, 2009; Kilroy et al., 2017). However, these changes take time to enact and may not always be possible. Therefore, teachers need resources and support through ongoing professional development from teacher educators and human resource development (HRD) practitioners who are responsive to where teachers’ discontentment lies (Southerland, Sowell, Blanchard, & Granger, 2011; Wilson, 2013). In doing so, we ensure that teachers have skills needed to be resilient members of their school organizations and professional communities as they continue to support and influence students’ career decisions.

Teachers Influence Students' STEM Aspirations

Teacher quality is the most important school-related factor in student achievement (RAND Corporation, 2012), and teachers can play an influential role in developing student interests and career aspirations (Sjaastad, 2012). This influence is especially apparent in STEM fields (Maltese & Tai, 2011). Quality STEM teachers have the potential to advance efforts to increase diversity of those entering STEM studies and help address the national shortfall of STEM workers. Students' decisions to pursue STEM careers are influenced by early school experiences (Fouad & Smith 1996; Fouad, Smith, & Zao 2002). Although there are other aspects of the STEM landscape that influence students' decisions to pursue STEM professions, the role that K-12 teacher's play is important. In the absence of highly qualified STEM teachers who remain in the profession long term, STEM career pathways lose an important link in the development of K-12 students into STEM professionals.

The STEM workforce has a significant impact on a nation's competitiveness, economic growth, and overall standard of living (Langdon, McKittrick, Beede, Khan, & Doms, 2011). The calls for meeting demands for STEM workers requires a 34% increase of STEM graduates per year (Xue & Larson, 2015). However, there are not enough students pursuing degrees or training in STEM to fill the jobs created over the next decade, and projections estimate a gap of approximately one million STEM professionals (Olson & Riordan, 2012). In response, within the STEM education community, there is a focused effort on broadening participation of those who traditionally pursue STEM studies (Hill, Corbett, & St. Rose, 2010; Ladson-Billings, 2000). Thus, within the culture of teacher attrition amid high professional standards, another expectation is now thrust upon teachers—increasing students' interests in pursuing STEM studies and careers.

Supporting STEM Teachers

Apart from or in addition to large-scale or systemic change (e.g., HIWP), many programs exist to support teachers. To date, most STEM teacher educators have focused on recruiting, preparing, and retaining STEM teachers. Current reform efforts have centered on changing teacher attitudes and practices around inclusivity and social justice (Ladson-Billings, 2000) to provide equitable access to learning for all students in STEM content. In this paper, we argue that simply focusing on inclusivity and social justice for students may not be sufficient. Resilient individuals continue to work and to restore their confidence, even in the face of adversity in the workplace (Luthans, Youssef, & Avolio, 2007). Therefore, teachers need professional development to support their personal skills to be adaptive in a dynamic educational landscape to build resilience to persist and thrive long-term in the education profession.

We present a theoretical and practical discussion about the application of research-based change models as they relate to the development of holistic teacher preparation programs. We ground our ideas in the well-examined Teacher-Centered Systemic Reform (TCSR) Model, a helpful framework for teacher educators to support teachers in reflecting on, modifying, and implementing professional practices (Clapp, 2017; Gibbons, Villafañe, Stains, Murphy, & Raker, 2018; Graves, Hughes, & Balgopal, 2016; Southerland et al., 2011; Woodbury & Gess-Newsome, 2002; Figure 2.1).

The TCSR model emerged from the self-efficacy literature (Bandura, 1997; Gibson, 2004) and explains that both personal and environmental (structural and cultural) contexts influence beliefs about teaching (Woodbury & Gess-Newsome, 2002). Subsequently, some of these beliefs influence behavior (professional practices), which may be in part due to the dynamic nature of the structural and cultural contexts of schools. Despite the TCSR model's

recognition of the importance of school and personal contexts (Alsup, 2006; Borman & Dowling, 2008; Darling-Hammond, 2010), it fails to account for changing professional landscapes. If teachers are unprepared to adapt to unpredictable and dynamic climates, they may leave the profession.

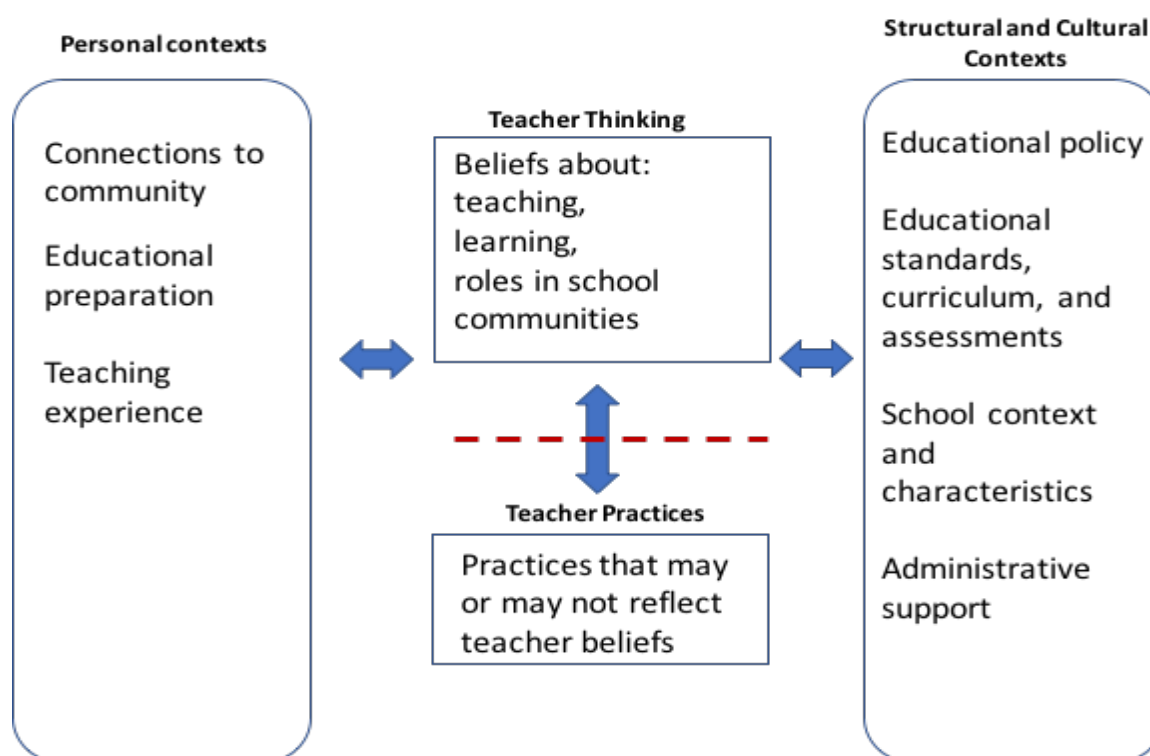


Figure 2.1. TCSR is a framework to understand how teachers' beliefs are shaped and may influence individual professional behaviors. Although beliefs can sometimes explain behaviors, other times teachers are unable to enact what they believe due to intrinsic or extrinsic reasons. Framework adapted from Woodbury & Gess-Newsome, 2002.

We argue that integrating dynamic professional environments with the TCSR model informs teacher PD leaders on how to meaningfully support novice and experienced teachers alike and increase their capacity to adapt to changing job demands. One example of the changing context is the recent adoption of national academic standards (e.g., Next Generation Science Standards (NGSS Lead States, 2013), Common Core State Standards (National Governors

Association Center, 2010) that teachers are expected to use to design instructional plans and assessments. Another example is new teacher evaluation policies (e.g., value-added models) to which teachers must respond to be promoted (Pitot, 2014).

As teacher educators and PD leaders, we have a specific interest in preparing teachers to respond to dynamic professional landscapes. We draw on literature from environmental conservation, human resource development, and teacher education to propose a creative modification of the TCSR model to account for the dynamic nature of structural and cultural contexts. We posit that this modified “TCSR to increase adaptive capacity” model, which we are currently testing, will inform the teacher PD community on how best to support STEM teachers to reduce attrition and increase job satisfaction.

Professional Resiliency

As novice teachers enter the workforce and tenured teachers shift schools, they must learn to navigate a new landscapes and unfamiliar contexts. Through social exchanges with staff, students, and community members, teachers construct meaning of and learn about the cultural values of this novel environment (Alsup, 2006; Lave & Wenger, 1991). This phenomenon is relevant for all teachers, but because STEM teacher attrition has been identified as a national problem, in particular it allows experts to examine which STEM teachers persist in the profession and under what conditions. One way to examine teacher behaviors within the education system, including how they respond to dynamic school environments, is through a social ecological system (SES) lens. SESs are typically described as the integration of different systems (e.g., social and bio-physical) and are composed of numerous actors, who interact across temporal and spatial scales. SESs are complex and adaptive, contain individual parts linked through feedback mechanisms, and each part displays resilience (Berkes, Colding, & Folke,

2008; Berkes, Folke, & Colding, 1998). Emergent properties of such systems cannot easily be anticipated, and because social networks are inherent to SESs, they account for local knowledge.

The concept of resilience is well-grounded and oft-studied in the field of environmental science and is described as having the capacity to buffer change, learn, and develop through adaptive behaviors (Folke, Carpenter, Elmqvist, Gunderson, Holling & Walker, 2002; Folke, Carpenter, Walker, Scheffer, Chapin, & Rockström, 2010). System dynamics, from an ecological perspective, can be examined using the adaptive cycle and its distinct phases: growth (r), maintenance (K), disturbance (Ω), and reorganization (α) (Chapin, Folke, & Kofinas, 2009; Figure 2.2). This model is helpful to understand how systems respond to changes as well as predict subsequent responses to disturbances (Ω) as indicated by the behaviors of individual parts of the system. Some systems quickly enter reorganization phases and move into a growth phase using adaptive responses. Other systems may push toward transformation over reorganization thereby pushing them in a new direction. Systems that enter growth phases typically maintain their adaptations through a period of conservation, until they experience subsequent disturbances (Ω). In this model, disturbances (Ω) need not be negative events; they are simply changes that require the system to respond.

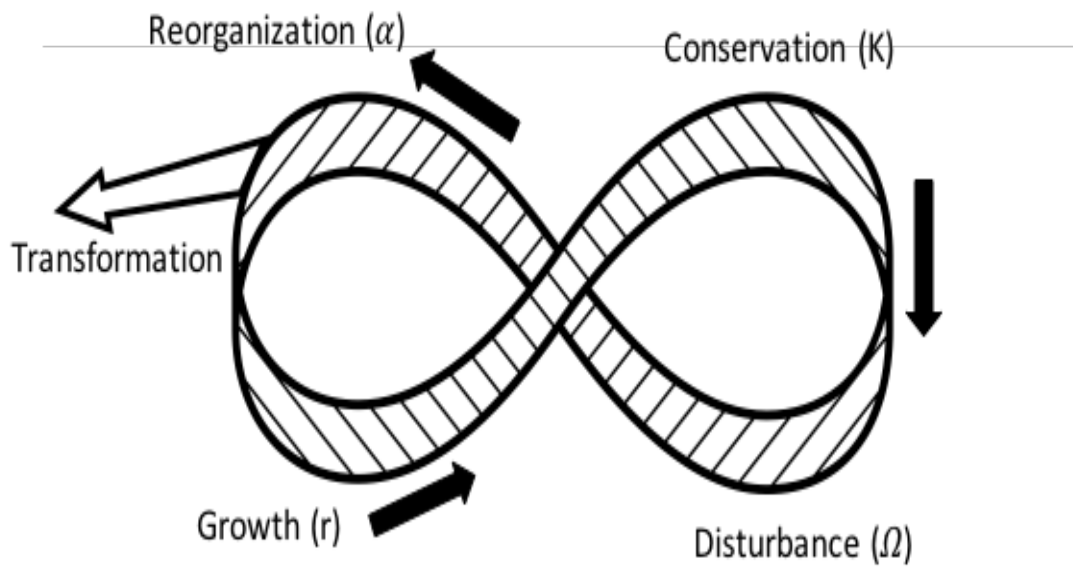


Figure 2.2. Adaptive cycle model (recreated from Holling & Gunderson, 2002). Systems comprised of individual parts experience different stages of response to disruption (disturbance, reorganization, growth, and conservation). Systems that remain relatively stable are considered to be resilience, whereas, systems that experience dramatic change may be transformed.

We believe that the SES model is informative to teacher educators and HRD practitioners because it allows us to recognize that, although education systems regularly experience disturbances, individual schools may not all respond in the same way or at the same time because of the actions of individual actors (e.g., faculty, staff, administrators, parents, students) within the system. Because, as Bhamra, Dani, and Burnard (2011) explained, resilience encompasses both organizations and individuals and how they react to turbulence. Teachers' capacities to be responsive to change should be developed in order to enhance both organizational and individual resilience, as the collective resilience of individuals will support the resilience of the organization itself (Lengnick-Hall, Beck, & Lengnick-Hall, 2011). By identifying the adaptive cycle phases, interventions and supports can be designed for teachers that are meaningful and promote adaptive practices that support and maintain system and professional resilience.

Professional resilience is likely related to personal or psychological resilience (Luthans, Vogelgesang, & Lester, 2006). Professional and human resource development that centers on building the strengths of individuals, increasing their self-efficacy, and attending to their performance capacities can, therefore, result in the psychological dimension of resiliency (Gibson, 2004). For example, resilient individuals demonstrate emotional stability, a willingness to adapt, and an openness to change (Luthans et al., 2006). At the system (or organizational) level, resilience is indicated by diversity, efficiency, adaptability, and cohesion (Fiksel, 2003). Both organizations and the individuals that make up the organization must have attributes that allow them to “weather the storm,” whether they transform or return to the previous state.

Taking an ecosystem-based approach allows experts to study whether the multiple components within schools and their communities work in tandem (Falk & Dierking, 2018). Resilient school ecosystems are those in which mutually beneficial relationships develop to support shared goals and can withstand perturbations (such as political or economic changes). In their descriptive case study of an elementary school in a low-resourced community in Portland, Oregon, Falk and Dierking (2018) identified how shifts to promote science education occurred over time. They found that leveraging informal science education partners in the community, while fostering support from school administrators and other leaders, was essential in enhancing the science learning infrastructure of the school. Moreover, they discovered that a community coordinator was an important link for students, connecting in-school and out of school learning and helping maintain students’ interests in STEM. We take a similar view of school ecosystems as being complex in nature and that allow synergistic relationships to form, yet we believe that understanding the role of the individual actors (i.e., teachers) is necessary if teacher educators and HRD experts are to support schools experiencing major changes. Falk and Dierking (2018)

focused on how school ecosystems affected individual students, and likewise, we present an approach that seeks to understand the needs of individual teaching professionals.

Case study of professional resilience

Our model is relevant to school environments and the issue of STEM teacher shortages. To illustrate how the adaptive cycle model can be helpful in describing school systems based on teacher actions, we present a case study of one elementary school that underwent all four phases of the adaptive cycle. Springwood Elementary School (a pseudonym for a public school in northern Colorado) experienced a disturbance (Ω) ten years ago when student numbers began to decrease, resulting in the redirection of monetary resources to other schools. In this district, parents can select which public school they want their children to attend, and district funds follow student enrollment. For Springwood Elementary to survive within the district, a reorganization (α) plan was necessary (Balgopal & Cornwall, 2010). The school improvement team determined that becoming a STEM-centric school was the best adaptive option. At this point, some teachers chose to leave the school because changing their teaching practices to fit a STEM model was inconsistent with their pedagogical beliefs and/or they were overwhelmed with the perceived effort involved (Southerland et al., 2011). Others chose to remain and participated in a period of system growth (r). Throughout the growth period, teachers learned ways to adapt their teaching to support STEM. They drew on resources in the community (e.g., PD leaders, local engineers and scientists, teacher educators, and STEM support educators) as well as their own collective understanding of STEM instruction and assessment.

Over time, teachers increased their collective capacity to integrate STEM into their daily routine, adapting their own beliefs and behaviors about teaching and learning to support system growth and maintenance at Springwood Elementary. After a few years, the principal left,

resulting in another system disturbance (Ω). As a plan was enacted to reorganize (α) under new leadership, the school embarked once again on the phases of the adaptive cycle, but the teachers maintained a collective resilience mindset to persist in an ever-changing educational landscape. In time, the STEM education professional identity of individual teachers was well-established at Springwood, which was illustrated when they moved to have their school name officially changed to Springwood STEM Elementary. The teachers who remained have demonstrated their personal adaptive capacity in the changing, transformed landscape of structural and cultural contexts that affected their school system. We believe that the organizational resilience that Springwood teachers and staff, as a collective, exhibited was because individuals were secure in both their personal and professional identities (Alsup, 2006). This may be because all the faculty/staff experienced the disruption at the same time and were able to strengthen their membership in the community. Beijaard, Verloop, and Vermunt (2000) found when teachers have perceptions of their professional roles that are shared by others at their school, they may feel more secure with their professional identities. Because Springwood STEM Elementary School adopted a new curricular, instructional, and administrative approach, they demonstrated adaptive capacity (Bhamra et al., 2011), yet the teachers, who chose to remain at the school and employed new practices, demonstrated professional resilience although they altered their teaching practices (Gu & Day, 2013).

Adaptive capacity is the key to resilience leading to growth (Berkes et al., 2008). Likewise, systems in place for developing the next generation of K-12 STEM educators demonstrate the same characteristics of complexity, feedback, and resilience. As pre-service teachers transform into novice and, eventually, master teachers, they experience multiple iterations of adaptation and growth. At an organizational level, Springwood STEM Elementary

School, moved through multiple iterations of the adaptive cycle as it transformed its current STEM culture. All systems exist and function on multiple scales of space, time, and social organization as do the individuals that comprise the system. Hence, we believe that what is missing from the typical STEM teacher preparation program is a critical examination of helping novice teachers build adaptive capacity skills to cope with dynamic school landscapes and changing education systems.

Building professional skills for resiliency in STEM teachers

Although many teacher education programs are attuned to current reform efforts and prepare novice teachers to meet such demands including those in STEM content areas, they do not necessarily help their graduates consider how they can respond to unexpected changes in their professional environment. All teachers need support. Our proposal to use an SES resilience lens can help teacher educators and HRD experts contextualize the needs of all practicing teachers, albeit our interests focus specifically on STEM teachers. We seek to positively influence STEM teachers' abilities to build resilience and to remain in the profession. Our desired ultimate end is for these teachers to encourage their students to pursue higher education degrees in STEM fields, and perhaps become classroom teachers themselves. Our revised TCSR model demonstrates the essential role that beliefs about personal adaptive capacity and a mind-set about professional resilience supports the adaptive capacity of the school system leading to increased system (organizational) resiliency as a salient outcome towards which PD leaders can design support (Figure 2.3) for individuals and for the system.

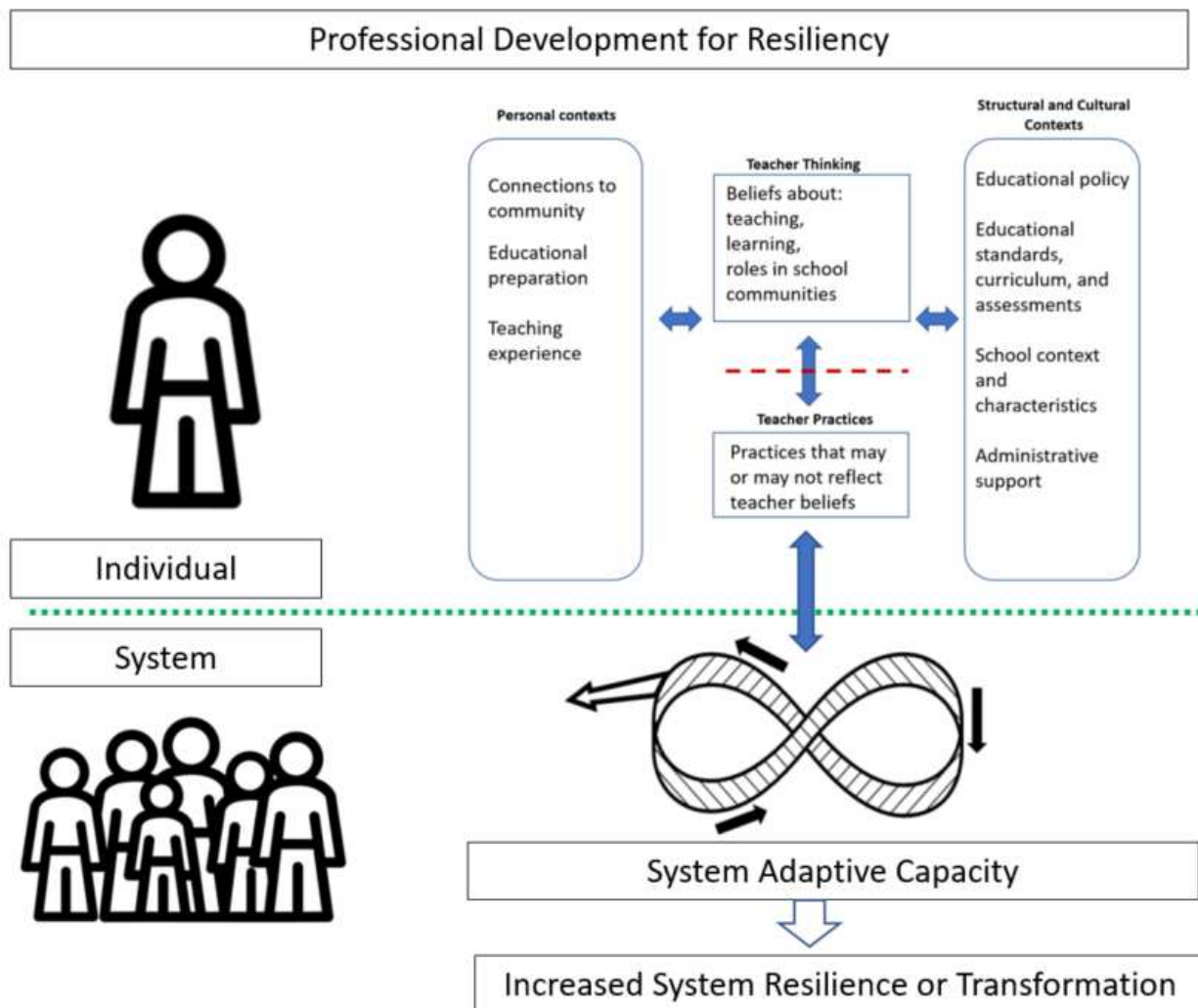


Figure 2.3. Revised TCSR-for resiliency (TCSR-R) model. The revised model explains that both personal and structural/cultural contexts influence teachers' beliefs about adaptability. When individuals' beliefs are able to adapt to a changing educational landscape, teachers' behaviors are also able to adapt to influence resiliency or transformation of the school system.

Adaptive STEM teachers are flexible and can design multiple pathways to meet teaching goals in dynamic professional landscapes. Adaptation is fundamental to long term persistence in any profession and should be viewed as the way the professional is engineered to be in harmony with the work environment (Gu & Day, 2007; Little, 1995). As in the original TCSR model (Figure 1), for which we noted that not all beliefs are enacted into practices, we recognize that simply being metacognitive about adaptive capacity and resilience is not sufficient for

demonstrating professional resilience. Teachers not only need the skills to be adaptive, but they must also weigh the pros and cons of expending energy to become adaptive (Alsup, 2006). In other words, the ability to adapt to stressors in the education environment is not a simple matter of negative feedbacks. It requires constant adjustment to system parts and even some changes in classroom structure in response to perturbations (Moran & Brondizio, 2013). Adaptation influences resilience and focuses on reducing vulnerabilities to specific threats, so teachers can remain in their profession and be good at their jobs.

Drawing on resilience frameworks used to examine SESs, we suggest that schools can be viewed as local systems for study with school districts and state education systems scaling up to national systems. Within the system there are numerous interconnected stakeholders competing for limited resources. Resilience supports persistence through change for both systems and individuals within it. It is measured in distance to potential thresholds for transformation (Nelson, 2011). In a continually changing education environment, individual teachers are constantly adapting and therefore, dynamically moving toward or away from transformational thresholds. Teachers who are aware of their personal thresholds can direct their adaptations to either maintain resilience in the current system or move toward positive (or sometimes negative) transformations. Without this awareness, thresholds may be crossed resulting in unintended transformation and the potential to exit the teaching profession. Teacher quality and teaching quality are distinct characteristics “since it is not only who teachers are that counts, but also what they do in the classroom.” (Gu & Day, 2013, p. xvii).

These outcomes have a measurable effect on developing a STEM workforce. In many states, licensed public school teachers of mathematics and science must have formal education in these disciplines, pass discipline-specific knowledge exams, and receive a license from the state

department of education acknowledging their preparation. Subsequently, to keep their license active, teachers seek continuing education credits in either pedagogy or content. These requirements ensure that practicing teachers are engaged in continuous learning, so they can be prepared to best address the needs of their students and the changing landscape of education. By designing and offering meaningful PD to practicing teachers, teacher educators can help increase the resilience of STEM teachers.

A “resilience mindset,” or psychological capacity for resiliency, requires being aware that aspects of both personal as well as educational, structural, and cultural contexts are dynamic (Luthans et al., 2006). This individual mindset precedes being adaptive to changing educational landscapes; however, some teachers may be more, or less aware of how their beliefs explain their practices. From our collective experiences, it is apparent that teachers seek PD opportunities for different reasons: some are fulfilling continuing education requirements, while others actively pursue options that challenge their current practices. According to Holling and Gunderson (2002), individuals with less adaptive capacity have a higher vulnerability to leaving the system once the system experiences a disturbance (Ω). In the professional context of teachers, this disturbance (Ω) can include new educational policy, standards, contexts, or administrators. Therefore, we posit that teachers who exhibit professional resilience must first develop their adaptive capacities. Richardson (2002) proposed that this first requires that the following are identified: resilient qualities of individuals and systems, processes of coping with stressors, and motivational forces to respond to stressors. We argue, therefore, understanding how teachers’ institutional and personal contexts influence their beliefs can inform teacher educators, who hope to support the development of both personal and professional resiliency.

Designing Meaningful Professional Development for STEM Teachers

STEM teachers need support and education in (a) meeting the diverse needs of their students, whose backgrounds vary linguistically, economically, socially, and culturally; (b) increasing content knowledge to meet the continually updated academic standards; (c) implementing culturally sustaining pedagogy and social justice to value inclusion (Paris, 2012; Thomas, Tran, & Dawson, 2010) and understand their role in encouraging and empowering youth to pursue STEM studies; and (d) becoming a part of local communities, so they can feel connected to the place where they live and work. In other words, all teachers need the skills and knowledge to accomplish their immediate goals as a teacher (needs a-c), but also the skills of becoming grounded in their community (need d). We believe this strongly applies to STEM teachers because of the recruitment and attrition problems specific to these content areas.

We are in the process of testing the revised TCSR model (Figure 3) with pre-service STEM teachers at Colorado State University who have committed to teaching in high-needs secondary schools. Through a series of PD workshops, students explore STEM content presented by university professors and engage in discussion related to social justice and high leverage teaching practices presented through vignettes. Experienced STEM teachers serving as mentors participate alongside pre-service STEM teachers to provide guidance in navigating potential tensions between personal and institutional contexts. The aim of the workshops is to develop the individual adaptive capacity of pre-service teachers to recognize their needs once they are employed, so they are prepared to build professional resilience within a school system. A secondary goal of the workshops is to support pre-service teachers as they begin to join communities of practice, both personal and professional, in their new school context. The “communities of practice” literature explains that professionals, including STEM teachers, often

belong to multiple communities of practice (professional, personal, and social), which can provide them with support and guidance as they navigate challenges at work (Balgopal, 2014; Lave & Wenger, 1991). Furthermore, feeling supported by colleagues is strengthened by membership in either formal or informal communities of practice (Alsup, 2006; Lave & Wenger, 1991).

Because many teacher education programs do not focus on potentially disruptive professional environments, teachers may feel unprepared for the realities of the profession. However, belonging to a community in which teachers can identify the skills they need to respond to policy, administrative, or cultural shifts in their schools is essential. Teacher PD leaders should be aware of this. Teachers need adaptive strategies and skills to become members of different communities of practice. By encouraging novice teachers to connect with their peers through professional communities and with their students, families, and local environment through social communities, we posit that they will feel more grounded in their schools and jobs. STEM teachers may feel like outsiders in communities in which they did not grow up or with which they identify. Skaalvik and Skaalvik (2011) found, in their study of over 2500 teachers in Norway, that teachers who left their jobs were either emotionally exhausted or felt a lack of belonging. Because communities of practice can offer support to teachers, including those who feel exhausted or unsupported, PD guidance on how to identify and become parts of communities (both professional and personal) can be valuable for STEM teachers. To meet this outcome, we argue that the adaptive capacity framework from environmental conservation can inform the types of PD that we believe must be developed.

Not only are resilient STEM teachers more likely stay in the profession and contribute to the resilience of their organizations, they are more likely to grow as quality teachers who can

engage and encourage students from diverse backgrounds to consider STEM studies and professions through positive interactions with students. Resilient teachers must be able to demonstrate a deep understanding of culturally sustaining pedagogies (Paris, 2012) that will enable them to respond to the languages, literacies, and cultural practices of students, parents, and colleagues. These knowledge and skills must be fostered in all novice STEM teachers. Resilient teachers not only know how to teach students to be science knowledge consumers and science knowledge producers, they teach students about the community of scientists. By doing so, they help their students value how science communities function (NGSS Lead States, 2013), which is necessary for students to build their own adaptive strategies and resilience if they choose to pursue science studies. This research can inform teacher PD and HRD experts on skills teachers need to help them stay in the profession.

Resilient STEM teachers adapt to the education environment by connecting with local community members as well (Goodpaster, Adedokun, & Weaver, 2012). When teachers become part of communities, they increase their local content knowledge as well as their physical and financial resources to support their teaching. These teachers demonstrate abilities to both create community and become a part of community. By modeling for their students the importance of working with others to identify problems and design solutions, teachers can encourage their students to develop critical thinking skills, while feeling grounded in relevant, local issues. Moreover, when teachers reach out to community members, the benefits are felt by many: local citizens are more aware of the schools in their communities, students have improved educational experiences and discover potential local career options, and teachers feel connected to/valued by those outside of the school walls. When teachers are part of a community that includes non-

teachers, they can share their successes, wonderings, and challenges with a broader circle allowing their needs to be known and legitimized.

Finally, resilient teachers are aware of their own limitations and seek PD, enabling continued personal growth. To encourage more novice teachers to be metacognitive, teacher educators must help them understand that seeking help is not a sign of weakness, rather, it is modeling for their own K-12 students the importance of lifelong learning. To develop these competencies, novice teachers need mentors, whether these are formal mentors assigned to them or informal mentors who teachers find on their own. Mentors, who are often more experienced educators, can help new teachers recognize that their sustained role in the school community can benefit students by encouraging them to persist in STEM studies, and potentially enter STEM professions (Hutchison, 2012). Because teachers' identities are reinforced or redefined at different levels, mentors who recognize this complexity in their own identity formation are likely in a better position to support novice teachers.

Concluding Thoughts

Teacher shortages have both short- and long-term implications. Although there is concern around recruitment of STEM teachers, our focus is on increasing STEM teacher retention—especially those in their first five years of teaching. Unfortunately, once novice teachers are overwhelmed and feel unprepared to juggle the needs of students, their families, administration, policy demands, and the content that they were hired to teach, they exit the profession. Those who stay must respond to dynamic classroom and school environments. Teacher PD programs for both preservice and in-service teachers must reflect that dynamic nature. To develop teachers who are well-equipped to be classroom leaders, holistic methodologies, including those that build resilience, should be employed (Brendel & Bennett, 2016). Hence, increasing teachers'

adaptive capacity to build resilience and persist in the teaching profession through the development of community building capacities is vital if the US is truly committed to preparing and supporting a diverse STEM workforce. By investing in PD of all teachers generally and STEM teachers specifically, we will discover the emerging property of functioning and productive STEM communities beginning in K-12 schools. Functional, productive groups are innovative. Individuals within these groups recognize the importance of each group member and their inputs, and the group demonstrates organizational self-efficacy (Gibson, 2004). We implore HRD practitioners and teacher educators who develop professional development programs for STEM teachers to design their programs so teachers have the opportunity to think about their own needs in changing professional landscapes, as they develop competencies to help diverse students thrive in school. If HRD professionals discuss changing school landscapes explicitly with teachers, they can reinforce the fact that teachers are a part of a system, an organization dependent on interconnected actors.

A first step to ensuring that the U.S. maintains a wide and diverse source of STEM professionals that help advance U.S. innovation and global competitiveness is enabling and encouraging equitable access to premium STEM education in K-12 schools (Hill et al., 2010). This begins with recruiting, training, and retaining highly qualified STEM teachers. When people feel supported by a community, they tend to want to remain in that community. Likewise, once diverse communities of Americans are recruited into STEM professions, it is important for them to have the capacity to stay, if they choose. If the US is to address the demand for more diverse STEM professionals, though, it must start in the K-12 setting, an institution that almost all Americans pass through before joining the workforce, with highly qualified STEM teachers for all students. Here, we call on our colleagues to go beyond traditional PD for STEM teachers

that solely focuses on student success and include interpersonal skills by guiding teachers as they identify and use available resources (e.g., communities of practice, curriculum, and PD) to build adaptive capacity leading to professional resilience.

Literature Cited

- Abel, M. H., & Sewell, J. (1999). Stress and burnout in rural and urban secondary school teachers. *The Journal of Educational Research*, 92(5), 287-293.
- Achinstein, B., Ogawa, R. T., Sexton, D., & Freitas, C. (2010). Retaining teachers of color: A pressing problem and a potential strategy for “hard-to-staff” schools. *Review of Educational Research*, 80(1), 71-107.
- Alsup, J. (2006). *Teacher identity discourses: Negotiating personal and professional spaces*. Mahwah, NJ: Routledge.
- Balgopal, M. M. (2014). Learning and intending to teach evolution: Concerns of pre-service biology teachers. *Research in Science Education*, 44, 27-52.
- Balgopal, M. M., & Cornwall, S. (2010). *Stakeholder discourse dynamics: A case study of an elementary school reform effort*. Paper presented at the annual conference of the National Association of Researchers in Science Teaching, Philadelphia, PA.
- Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: Freeman.
- Beijaard, D., Verloop, N., & Vermunt, J. D. (2000). Teachers’ perceptions of professional identity: An exploratory study from a personal knowledge perspective. *Teaching and Teacher Education*, 16(7), 749-764.
- Berkes, F., Colding, J., & Folke, C. (Eds.). (2008). *Navigating social-ecological systems: building resilience for complexity and change*. Cambridge, UK: Cambridge University Press.
- Berkes, F., Folke, C., & Colding, J. (Eds.). (1998). *Linking social and ecological systems: Management practices and social mechanisms for building resilience*. Cambridge, UK: Cambridge University Press.
- Bhamra, R., Dani, S., & Burnard, K. (2011). Resilience: the concept, a literature review and future directions. *International Journal of Production Research*, 49(18), 5375-5393.
- Borman, G. D., & Dowling, N. M. (2008). Teacher attrition and retention: A meta-analytic and narrative review of research. *Review of Educational Research*, 78(3), 367-409.

- Boxall, P., & Macky, K. (2009). Research and theory on high-performance work systems: Progressing the high-involvement stream. *Human Resource Management Journal*, 19, 3-23.
- Boyd, D., Lankford, H., Loeb, S., & Wyckoff, J. (2005). The draw of home: How teachers' preferences for proximity disadvantage urban schools. *Journal of Policy Analysis and Management*, 24(1), 113-132.
- Brendel, W., & Bennett, C. (2016). Learning to embody leadership through mindfulness and somatics practice. *Advances in Developing Human Resources*, 18(3), 409-425.
- Chapin, F. S., Folke, C., & Kofinas, G. (2009). A framework for understanding change. In F.S. Chapin, G. Kofinas, C. Folke (Eds.) *Principles of ecosystem stewardship: Resilience-based natural resource management in a changing world* (pp. 3-28). New York, NY: Springer.
- Clapp, F. N. (2017). *Teachers' and researchers' beliefs of learning and the use of learning progressions* (Doctoral dissertation, Colorado State University).
- Cowan, J., Goldhaber D., Hayes K., & Theobald R. (2016). Missing elements in the discussion of teacher shortages. *Educational Researcher*, 45(8), 460-462.
- Darling-Hammond, L. (1997). *Doing what matters most: Investing in quality teaching*. Washington, DC: National Commission on Teaching and America's Future.
- Darling-Hammond, L. (2010). Recruiting and retaining teachings: Turning around the race to the bottom in high-needs schools. *Journal of Curriculum and Instruction*, 4(1), 16-32.
- Darling-Hammond, L., & Bransford, J. (Eds.). (2007). *Preparing teachers for a changing world: What teachers should learn and be able to do*. San Francisco, CA: John Wiley & Sons.
- Falk, J. H., & Dierking, L. D. (2018). Viewing science learning through an ecosystem lens: A story in two parts. In D. Corrigan, C. Bunting, A. Jones, & J. Loughran (Eds) *Navigating the Changing Landscape of Formal and Informal Science Learning Opportunities* (pp. 9-29). Cham, Switzerland: Springer.
- Fiksel, J. (2003). Designing resilient, sustainable systems. *Environmental Science and Technology*, 37 (23), 5330–5339.
- Folke, C., Carpenter, S., Elmqvist, T., Gunderson, L., Holling, C. S., & Walker, B. (2002). Resilience and sustainable development: building adaptive capacity in a world of transformations. *AMBIO: A journal of the human environment*, 31(5), 437-440.

- Folke, C., Carpenter, S., Walker, B., Scheffer, M., Chapin, T., & Rockström, J. (2010). Resilience thinking: integrating resilience, adaptability and transformability. *Ecology and society*, 15(4), 20.
- Fouad, N. A., & Smith, P. L. (1996). A test of a social cognitive model for middle school students: Math and science. *Journal of Counseling Psychology*, 43(3), 338.
- Fouad, N. A., Smith, P. L., & Zao, K. E. (2002). Across academic domains: Extensions of the social-cognitive career model. *Journal of Counseling Psychology*, 49(2), 164.
- Gibbons, R. E., Villafañe, S. M., Stains, M., Murphy, K. L., & Raker, J. R. (2018). Beliefs about learning and enacted instructional practices: An investigation in postsecondary chemistry education. *Journal of Research in Science Teaching*. Retrieved from: <https://onlinelibrary.wiley.com/doi/abs/10.1002/tea.21444>.
- Gibson, S. K. (2004). Social learning (cognitive) theory and implications for human resource development. *Advances in Developing Human Resources*, 6(2), 193-210..
- Gist, C. D. (2018). Human Resource Development for Racial/Ethnic Diversity: Do School Systems Value Teachers of Color? *Advances in Developing Human Resources*, 20(3), 345-358.
- Goodpaster, K. P., Adedokun, O. A., & Weaver, G. C. (2012). Teachers' perceptions of rural STEM teaching: Implications for rural teacher retention. *Rural Educator*, 33(3), 9-22.
- Graves, L. A., Hughes, H., & Balgopal, M. M. (2016). Teaching STEM through agriculture: Implementation of an edible plant curriculum at an elementary school. *Journal of Agricultural Education*, 57(3), 192-207.
- Gu, Q., & Day, C. (2007). Teachers resilience: A necessary condition for effectiveness. *Teaching and Teacher education*, 23(8), 1302-1316.
- Gu, Q., & Day, C. (2013). *Resilient teachers, resilient schools: Building and sustaining quality in testing times*. New York, NY: Routledge.
- Guarino, C. M., Santibanez, L., & Daley, G. A. (2006). Teacher recruitment and retention: A review of the recent empirical literature. *Review of Educational Research*, 76(2), 173-208.
- Hanushek, E. A., Kain, J. F., & Rivkin, S. G. (1999). *Do higher salaries buy better teachers?* (Working Paper No. 7082). Cambridge, MA: National Bureau of Economic Research.

- Haynes, M. (2014). On the path to equity: Improving the effectiveness of beginning teachers. *Alliance for Excellent Education*.
- Henke, R., Chen, X., & Geis, S. (2000). *Progress through the teacher pipeline: 1992-93 college graduates and elementary/secondary school teaching as of 1997*. Washington, DC: National Center for Education Statistics, U.S. Department of Education.
- Hill, C., Corbett, C., & St. Rose, A. (2010). *Why so few? Women in science, technology, engineering, and mathematics*. American Association of University Women. 1, Washington, DC.
- Holling, C. S., & Gunderson, L. H. (2002). Resilience and adaptive cycles. In: *Panarchy: Understanding Transformations in Human and Natural Systems*, 25-62.
- Hutchison, L. F. (2012). Addressing the STEM teacher shortage in American schools: Ways to recruit and retain effect STEM teachers. *Action in Teacher Education*, 34(5-6), 541-550.
- Ingersoll, R. M. (2001). Teacher turnover and teacher shortages: An organizational analysis. *American Educational Research Journal*, 38(3), 499-534.
- Ingersoll, R. M. (2002). The teacher shortage: A case of wrong diagnosis and wrong prescription. *NASSP bulletin*, 86(631), 16-31.
- Ingersoll, R. M. (2003). *Is there really a teacher shortage?* Seattle: University of Washington, Center for the Study of Teaching and Policy.
- Ingersoll, R. M., & May, H. (2011). The minority teacher shortage: Fact or fable?. *Phi Delta Kappan*, 93(1), 62-65.
- Ingersoll, R. M., Sirinides, P., & Dougherty, P. (2018). Leadership matters: Teachers' roles in school decision making and school performance. *American Educator*, 42(1), 13.
- Jacob, B. A. (2007). The challenges of staffing urban schools with effective teachers. *The Future of Children*, 129-153.
- Kaigher, A. (2011). Beginning Teacher Attrition and Mobility: Results from the First through Third Waves of the 2007-08 Beginning Teacher Longitudinal Study. First Look. NCES 2011-318. *National Center for Education Statistics*. Retrieved on 11/17/2017 from <https://eric.ed.gov/?id=ED523821>

- Kilroy, S., Flood, P. C., Bosak, J., & Chênevert, D. (2017). Perceptions of high-involvement work practices, person-organization fit, and burnout: A time-lagged study of health care employees. *Human Resource Management, 56*(5), 821-835.
- Kirby, S. N., & Grissmer, D. W. (1991). Sources of teacher supply: Some new evidence from Indiana. *Educational Evaluation and Policy Analysis, 13*, 256–268.
- Ladson-Billings, G. (2000). Fighting for our lives: Preparing teachers to teach African American students. *Journal of Teacher Education, 51*(3), 206-214.
- Langdon, D., McKittrick, G., Beede, D., Khan, B., & Doms, M. (2011). STEM: Good Jobs Now and for the Future. ESA Issue Brief# 03-11. *US Department of Commerce*.
- Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, UK: Cambridge University Press.
- Lee, O., Maerten-Rivera, J., Penfield, R. D., LeRoy, K., & Secada, W. G. (2008). Science achievement of English language learners in urban elementary schools: Results of a first-year professional development intervention. *Journal of Research in Science Teaching, 45*(1), 31-52.
- Lengnick-Hall, C. A., Beck, T. E., & Lengnick-Hall, M. L. (2011). Developing a capacity for organizational resilience through strategic human resource management. *Human Resource Management Review, 21*(3), 243-255.
- Little, M. A. (1995). Adaptation, adaptability, and multidisciplinary research. *Biological Anthropology. The State of the Science. International Institute for Human Evolutionary Research. Oregon*, 121-148.
- Luthans, F., Vogelgesang, G. R., & Lester, P. B. (2006). Developing the psychological capital of resiliency. *Human Resource Development Review, 5*(1), 25-44.
- Luthans, F., Youssef, C. M., & Avolio, B. J. (2007). *Psychological capital: Developing the human competitive edge* (Vol. 198). Oxford: Oxford University Press.
- Maltese, A. V., & Tai, R. H. (2011). Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among US students. *Science Education, 95*(5), 877-907.
- McLeskey, J., & Billingsley, B. S. (2008). How does the quality and stability of the teaching force influence the research-to-practice gap? A perspective on the teacher shortage in special education. *Remedial and Special Education, 29*(5), 293-305.

- Moran, E. F., & Brondizio, E. S. (2013). Introduction to human-environment interactions research. In: *Human-Environment Interactions. Current and Future Directions*. (pp. 1-24). New York: Springer.
- National Governors Association Center for Best Practices, Council of Chief State School Officers (2010). *Common Core State Standards for Mathematics*, Washington D.C.: National Governors Association Center for Best Practices, Council of Chief State School Officers.
- NGSS Lead States. 2013. *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press.
- Nelson, D. R. (2011). Adaptation and resilience: responding to a changing climate. *Wiley Interdisciplinary Reviews: Climate Change*, 2(1), 113-120.
- Olson, S., & Riordan, D. G. (2012). Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics. Report to the President. *Executive Office of the President*. Retrieved from: <https://files.eric.ed.gov/fulltext/ED541511.pdf>
- Paris, D. (2012). Culturally sustaining pedagogy: A needed change in stance, terminology, and practice. *Educational Researcher*, 41(3), 93-97.
- Pitot, L. N. (2014). *Determining the alignment between what teachers are expected to teach, what they know, and how they assess scientific literacy* (Doctoral dissertation, Colorado State University).
- RAND Corporation (2012). *Teachers Matter: Understanding Teachers' Impact on Student Achievement*. Santa Monica, CA: RAND Corporation. https://www.rand.org/pubs/corporate_pubs/CP693z1-2012-09.html.
- Richardson, G. E. (2002). The meta-theory of resilience and resiliency. *Journal of Clinical Psychology*, 58, 307-321.
- Showalter, D., Klein, R., Johnson, J., & Hartman, S. L. (2015). *Why rural matters: Understanding the changing landscape innovation and practice in rural education*. Retrieved from: http://www.ruraledu.org/user_uploads/file/WRM-2015-16.pdf
- Sjaastad, J. (2012) Sources of Inspiration: The role of significant persons in young people's choice of science in higher education. *International Journal of Science Education* 34(10), 1615-1636

- Skaalvik, E. M., & Skaalvik, S. (2011). Teacher job satisfaction and motivation to leave the teaching profession: Relations with school context, feeling of belonging, and emotional exhaustion. *Teaching and Teacher Education*, 27(6), 1029-1038.
- Southerland, S. A., Sowell, S., Blanchard, M., & Granger, E. M. (2011). Exploring the construct of pedagogical discontentment: A tool to understand science teachers' openness to reform. *Research in Science Education*, 41(3), 299-317.
- Sutcher, L., Darling-Hammond, L., & Carver-Thomas, D. (2016). A coming crisis in teaching? Teacher supply, demand, and shortages in the US. *Learning Policy Institute*. Retrieved from <https://learningpolicyinstitute.org/product/coming-crisis-teaching>.
- Tait, M. (2008). Resilience as a contributor to novice teacher success, commitment, and retention. *Teacher Education Quarterly*, 35(4), 57-75.
- Thomas, K. M., Tran, N. M., & Dawson, B. L. (2010). An inclusive strategy of teaching diversity. *Advances in Developing Human Resources*, 12(3), 295-311.
- Wilson, S. M. (2013). Professional development for science teachers. *Science*, 340(6130), 310-313.
- Woodbury, S., & Gess-Newsome, J. (2002). Overcoming the paradox of change without difference: A model of change in the arena of fundamental school reform. *Educational Policy*, 16(5), 763-782.
- Xue, Y., & Larson, R. (2015). STEM crisis or STEM surplus? Yes and yes. *Monthly Labor Review*, U.S. Bureau of Labor Statistics. Retrieved on 11/17/2017 from <https://doi.org/10.21916/mlr.2015.14>.

CHAPTER 3

MIDDLE SCHOOL SCIENCE TEACHERS' AGENCY TO IMPLEMENT PLACE-BASED EDUCATION CURRICULA ABOUT LOCAL WILDLIFE²

There has been a recent growth and interest in the field of urban ecology (Forman, 2014; Soulsbury & White, 2016), a particularly relevant topic for K-12 students to explore because lessons can often be adapted to be locally relevant. Place-based education (PBE) uses the local context as a starting point to teach students about interconnected social-ecological systems with intentions to encourage civic engagement (Woodhouse and Knapp, 2000; Smith, 2002; Gruenewald, 2003b; Sobel, 2004). However, PBE is more. It can increase both environmental and civic literacy, where literacy is defined as having both content knowledge about a topic (i.e. the environment and civics) and the ability to apply that knowledge to answer questions and take actions related to that topic (Roberts & Bybee, 2014). Furthermore, because time spent outdoors as children is directly associated with increased environmental literacy, it makes sense for environmental educators to explore strategies to help teachers engage youth in outdoor activities (Pittman et al., 2018). Therefore, increasing engagement with and understanding of the local natural environment through outdoor activities can increase a person's connection to and sense of belonging in that place (Semken & Freeman, 2008; Kudryavtsev, Krasny, & Stedman, 2012). Understanding the local environment includes not only knowing about natural areas, but examining how local social structures can impact community and individual behaviors in such areas. Although teachers may be receptive to implementing PBE curricula, if they have

² Published as Wright, D. S., Crooks, K. R., Hunter, D. O., Krumm, C. E., & Balgopal, M. M. (2021). Middle school science teachers' agency to implement place-based education curricula about local wildlife. *Environmental Education Research*, 27(10), 1519-1537.

insufficient experience creating, observing, or participating in lessons, they may not feel prepared to teach using this approach. This paper explores how middle school teachers in one community make decisions about using PBE lessons designed around urban ecology.

Place Based Education

Connecting natural and social systems allows teachers to guide interdisciplinary learning (Gruenewald, 2003a); however, PBE is inconsistently defined across research studies. Smith (2002) focused solely on *place*, whereas Greenwood (2008) viewed PBE as a critical pedagogy for decolonization. Bowers (2008) argued that PBE should rely on intergenerational knowledge to incorporate historical and cultural aspects of place. Kudryavtsev et al. (2012) and Ardoin (2006) claimed that the development of a *sense of place* (e.g. a connection to place through place attachment and place meaning) in PBE should be front and center. More recently, Cruz et al. (2018) advocated for a funds of knowledge and social capital approach to PBE, drawing on the cultural and personal knowledge learners bring to lessons. Others argue that the use of local resources requires the engagement of and collaboration between schools and community organizations thereby developing numerous connections among community members (Nagel, 1996). We adapted and integrated definitions described by Woodhouse and Knapp (2000), Gruenewald (2003a), and Smith and Sobel (2010). In our research, we define PBE lessons as those that: (1) are inspired by local cultural or biophysical context or issue, (2) allow school and community organizations or experts to collaborate, (3) integrate interdisciplinary content, (4) use inquiry and experiential pedagogy, and (5) are designed to encourage civic engagement.

The primary value of PBE is to strengthen a person's connection to the people and places in which they live and to promote local civic engagement. Potential outcomes of the strengthened connection provide benefits to both people and natural places. People may

experience (1) improved livelihoods, (2) a change in behaviors that favor conservation strategies, (3) increased civic engagement, (4) positive change in local economics, or (5) increased pride in being a part of the local area (Gruenwald & Smith, 2014; Dale et al., 2020). The bio-physical environment may experience (1) recovery from previous ecosystem degradation, (2) increases in biodiversity, or (3) sustainable use of ecosystem services (Smith, 2007).

Scholars argue that PBE develops inquiry skills, values clarification, and reinforces problem solving (Knapp, 1985; Gruenewald, 2003b). Not only does PBE prepare students to become informed citizens, it prompts them to examine issues and make thoughtful choices that have multidimensional effects on the social and natural environment (Knapp, 1985, 2005; Flanagan & Gallay, 2014; Gallay et al., 2016). Because of the exploration of social issues when studying ecological topics, Smith (2007) and Greenwood (2008) argued that PBE is a form of critical pedagogy offering opportunities for learners to engage with issues of race, gender, class, and culture. Hence, PBE pushes teachers and students to critically examine how use of and changes to natural areas affects community groups, including themselves. The numerous benefits of PBE, including increased student desire for learning (Ernst & Monroe, 2004) and attachment to the broader community (Flanagan et al, 2019), are well recognized (Smith, 2002; Gruenewald & Smith, 2008).

In spite of the depth and breadth of research on PBE and how it benefits students, including how it impacts their environmental and civic literacy, why and how teachers choose to use PBE in their classroom is understudied and undertheorized. Of the few studies that examine teachers' decisions about implementing PBE, findings focus on teachers' structural reasons (administrative support, weather) for inconsistent implementation (e.g., Linnemanstons & Jordan, 2017; Miller & Twum, 2017). However, there is a rich literature that examines the

complex reasons around teachers' pedagogical decisions (e.g., Roehrig & Kruse, 2005; Tao & Gao, 2017; Woodbury & Gess-Newsome, 2002). Our goals were to more deeply investigate teacher use of PBE lessons beyond solely structural reasons. We examined how middle school science teachers made sense of and implemented PBE curricular resources as they addressed academic standards related to ecology to increase environmental literacy in students.

Recognizing that adoption, adaptation, or rejection of PBE materials by teachers can be influenced by their agency in a particular context (Balgopal, 2020), we used teacher agency as a framework to design our study and analyze the findings.

Theoretical Framework

Teacher Agency

When teachers are able to actively contribute to the design of curricula, they exhibit agency in shaping the conditions of their classroom (Beista et al., 2015). Agency consists of different yet simultaneous orientations or elements toward shaping the actions teachers take (Emirbayer & Mische; 1998). The first element is *iterational*; teacher thinking is influenced by past personal and professional history. The second element, *projective*, describes how teachers look toward possible future benefits, while the third element is how the teacher engages with the *present*. As teachers think about their practices in the classroom, all three elements of agency influence decisions on whether or not to take action. Teacher agency can be developed and shaped by both extrinsic (e.g., mentors) and intrinsic (e.g., psychological resilience) variables (Balgopal, 2020). When teachers capitalize on their personal and contextual resources, they have the power to take control of their situation and solve problems, prompting Biesta and Tedder (2007) to purport that people achieve, rather than have, agency. Therefore, to study agency, it behooves researchers to identify what variables influence teachers as they make curricular

decisions about environmental concepts and whether these decisions are driven by external factors or by teachers themselves (Spence et al., 2013).

Research on teacher agency is informed by social cognitive theory, which describes learning as a largely social process based on observing others (Bandura, 1997; Sullivan et al., 2012). Teachers develop skills through collaborative learning and observation of master teachers then attempt to implement the skills in their own classroom (Sullivan et al., 2012). When a teaching style demonstrates positive results for students, it is more likely to be repeated. Teachers draw on both intrinsic (personal) and extrinsic (structural/cultural) variables that shape their beliefs and subsequent behaviors in the classroom (Woodbury & Gess-Newsome, 2002). However, these variables alone do not explain why some individuals may be motivated or not to change behaviors, as when making choices about what and how to teach science (Addy & Blanchard, 2010; Furtak, 2012; Spence et al., 2013).

The following question drove our study: What factors influence middle school science teachers to adapt their instructional approaches to implement PBE lessons on urban ecology?

Methods

Both constructivist and sociocultural research orientations assume that human behavior is affected by surrounding social and cultural factors (Guba & Lincoln, 1994; Lee, 2012). In other words, personal experiences and structural/cultural contexts influence how teachers think about curriculum and instruction and their subsequent choices as teachers (Woodbury & Gess-Newsome, 2002). Teacher beliefs alone, however, do not determine their thinking about changes in their practice (Balgopal, 2020). The elements of past experiences and potential future trajectories also play a role in teachers' beliefs as they determine the level of effort needed to take action. This constructivist grounded theory study was designed to understand how middle

school teachers in one district chose to adopt, adapt, or reject PBE curriculum. The five tenets of the Chicago School of grounded theory call on researchers to 1) establish trust with participants, 2) focus on many forms of communication, 3) document how people communicate, 4) maintain sensitivity to how meaning is ascribed to objects and terms, and 5) describe how terms and symbols are used in communication (Charmaz, 2005). We established trust with teachers through prolonged engagement, leveraging the relationship that the first author had with the teachers and school district as a perceived colleague. This position also helped our research team develop an in-depth understanding of the institutional context of the teachers, the policies to which teachers adhered, and school demographics.

Context

Beginning in Fall 2017, a collaboration was established between Riverside School District (RSD, a pseudonym) middle school science teachers, university researchers, and a non-profit conservation organization dedicated to protection of wildlife in the western US mountain region to use wildlife camera traps located near schools to learn about local urban wildlife. Camera traps are an increasingly popular tool to survey wildlife populations as they are low-cost, non-invasive and highly effective (O'Connell et al., 2011). They are used in wildlife research to provide unambiguous evidence of species occurrences that are easily identifiable and permanently available for use (Kays, 2016; Nugent, 2017). A professor of wildlife and conservation biology acquired additional funds to support teachers (Research Experience for Teachers) as part of a federal grant to study urban wildlife interactions. Through these funds, teachers were provided cameras, compensation for time and effort for participation, and funding to cover substitute teachers in order to attend professional development workshops focused on learning about a PBE approach to pedagogy and implementation of ecology curriculum. The

non-profit organization, with the support of RSD teachers, developed a PBE curriculum, including lesson activities and assessments to help teachers incorporate the photographic data generated by the cameras into classroom learning. All of the public school teachers who participated in this study were expected by their schools to adhere to standards-based lessons. Therefore, the PBE lessons were aligned with the national Next Generations Science Standards (NGSS) that were developed in the U.S. in 2013 to help states define their own academic standards. Lessons prompted students to monitor wildlife in their school “backyards” while sparking discussion about human-wildlife interactions and conservation efforts. Open-ended inquiry questions about ecological phenomena including using photographic data from camera traps prompted students to ask questions, search for patterns, and draw conclusions about local urban wildlife. Professional development workshops were held four times and covered topics such as using a camera trap, data organization, writing to learn to make sense of photographic data, place-based education components, and ideas for middle school student civic engagement about local natural areas. Each workshop also included time for teachers to share ideas on using the data with their students. All workshop content was aligned with Next Generation Science Performance Expectations for Middle School Life Science (Appendix A). This study was considered ethical and was approved by both [University] and [School District] Institutional Review Boards (protocol 329-18H).

Curriculum

The co-created PBE curriculum designed by teachers and the non-profit organization centered on the big question “What can we learn from a picture?” and aligned with NGSS performance expectations for middle school for life science (Appendix A). The curriculum storyline included inquiries using the photographic data to draw conclusions from what is seen

and not seen in the photographs to determine local food webs and energy transfer through the ecosystem. Having photographic data from multiple sites provided the opportunity to compare the urban wildlife present across RSD. A map of camera locations led students to consider human impacts on natural environments. Teachers were provided digital access to the PBE curriculum and encouraged to modify the lessons to meet the needs of their student population. The curriculum outline can be viewed in Appendix B.

Participants

All science teachers from 12 middle schools in RSD were recruited to participate in this project. Ultimately, 11 teachers from 10 schools chose to participate. They were asked to place a remote wildlife camera in natural areas on or near school property with support of the non-profit organization in gaining permissions and purchasing hardware and consider how they might use the picture data in their teaching. One teacher had previously used camera traps personally and in the classroom while all the others were new to the technology. Participant experience ranged from first year teaching to 28 years of experience (Appendix C). Site-based management in RSD allows for each school community to determine a school focus to meet the needs of students within that attendance area. Class length is also determined by each school and in accordance with state requirements. Class sizes vary based on student population size and schedules. All names presented are pseudonyms.

Data collection

The first author spent 60 hours observing, interviewing (both formally and informally) participants, and reviewing curricular artifacts including lesson plans, presentations and student handouts that participants shared with us. Participants were observed as they were implementing PBE lessons either in classrooms or outdoors on field trips near their respective schools. All

observations were recorded as field notes. As with grounded theory studies, interviews were the primary data source and observational field notes and analysis of curricular materials were used to triangulate findings. Twelve hours of interviews were recorded and transcribed for analysis.

With the support of the non-profit organization in placing and maintaining cameras, the cameras were functional from Fall 2017 to Winter 2019 generating photograph data of wildlife (e.g., bobcats, coyotes, red foxes, raccoons, and deer) for teachers to access and use in their PBE lessons. Over that time, participating teachers were interviewed using a semi-structured interview protocol (Appendix D) for an average total time of 60 minutes per teacher. An initial interview allowed the first to reconnect with teacher participants with whom she had previously worked as the RSD Science Curriculum Facilitator to inquire about pedagogical practices and desired involvement in the camera trap project. In the second year of the project, a follow-up interview focused on the implementation of the five PBE components using the camera data. Each teacher was observed at least two times, either in their classroom teaching the PBE lessons or while on outdoor excursions to camera locations. During observations, parts of lessons were either video recorded or documented in detailed field notes. In addition, teachers shared their instructional artifacts (handouts, assessments) with us. The data were organized for each teacher, along with their demographic information, allowing us to develop cases for analysis.

Data analysis

Interview and artifact data collected during multiple interviews and observations were transcribed. Initial open coding occurred using an iterative process. We initially identified patterns following methods described by Charmaz (2020), who advocates for the use of sensitizing concepts to help “open inquiry rather than to mold it into a previously established theoretical framework” (p. 168). Open codes included background, identity, academic standards,

and school structure as examples. These open codes were then collapsed into four axial codes: reflective practice, reflexive practice, instructional context, and classroom context.

Subsequent coding occurred by identifying intrinsic and extrinsic variables described by participants using RQDA software (Charmaz, 2020). Selective codes included agency and alignment. We recognized that teachers' instructional choices are influenced by their intrinsic (e.g., personal) and extrinsic (e.g., structural and cultural) contexts, so teachers' comments about why or how they chose to implement PBE lessons were organized into these contextual categories. (Woodbury & Gess-Newsome, 2002). The data were then reanalyzed with a focus on participant connections to the environment and to education, which were collapsed into themes of how the data described teacher practices and contexts (Appendix E). The first set of interviews and codes were used to inform subsequent interviews, observations, and artifact collection. From these, final propositions were determined.

Trustworthiness

To establish trustworthiness and reduce bias in the study, authors co-coded 20% of the same interview transcripts, and the first author coded artifacts. In the process, research questions were revised as the code book was clarified. After a period of time, the data were reviewed for potential re-coding as part of an iterative process to establish intra-rater reliability (Creswell & Poth, 2016; Creswell & Creswell, 2017). Once transcription for the second set of interviews was complete, an inter-rater coder was trained and analyzed 20% of the transcripts. The inter-rater reliability was 80% and all discrepant codes were discussed and clarified until full agreement was met. The findings were shared with a group of teacher educator research peers through a process of peer debriefing. Although the debriefing did not result in revising our codes, it challenged us to ensure that our claims were supported with evidence. Once transcripts were

coded, we used data triangulation to ensure that our final codes could be supported by other sources of data (curricular artifacts, observational notes, and videos of lessons). Teacher lesson plans demonstrated opportunities to collaborate with community experts while student notebooks indicated action items for harmonious human-wildlife coexistence.

Positionality

The first has been a K-12 teacher and teacher educator for the past 26 years. She worked in district elementary and middle schools for five years and was the district science curriculum facilitator for six years in the school district in which this study took place. As a science classroom teacher, the first sought opportunities to connect content to real-world scenarios to enhance student understanding beginning with local contexts then expanding out to a global view. She has continued to participate in social and professional gatherings with teachers in the district, and in this way, we assumed she had built trust with the participants of this study. The second is a former secondary science teacher and science teacher educator, having taught science methods and/or leading pedagogy workshops for the past 15 years. During this time, she has been studying EE and PBE, and recently has been conducting work in the Global South using UNESCO's Education for Sustainable Development framework. Subsequent s provided grant funding and project support to teacher participants. The other co-s all have extensive experience using camera traps and engaging with the public (i.e., speaking on public radio, giving community presentations, collaborating with educators) about urban wildlife issues.

Findings

Based on their decisions to implement the components of PBE while using the camera trap photographs and curriculum, we classified teachers into four categories (*implementer, partial implementer, non-implementer, and non-responder* (Table 3.1). Categories were defined

based on the presence or absence of (1) teacher-perceived instructional and class context *alignment* and (2) teacher *agency* over their own curricular choices (Figure 3.1). Alignment refers to academic standards (i.e., instructional context) and classroom structure. Academic standards drive the curricular content a teacher chooses to implement in their classroom followed by methods for teaching that content. For example, all participants taught about the flow of energy in ecosystems through food chains and food webs. Teachers identified as implementers chose to incorporate data from the local camera traps, whereas, partial and non-implementers continued to use previous materials. Teachers who chose to use the accompanying urban wildlife curriculum saw a direct connection between academic standards, the content of the photographs, and how to use them with students to advance environmental literacy. A teacher's level of agency influenced whether or not and to what degree they chose to specifically use the PBE camera trap curricula. The teachers who achieved curricular agency were able to be reflective and reflexive in drawing on background experiences that elevated their curiosity about their local natural environment. They felt their local natural and social environment was relevant for students to learn content, connect with community partners, and become thoughtful and engaged citizens.

Table 3.1. Place-based education characteristics. Middle school science teachers incorporated the five components of PBE differently in relationship to their implementer status.

<i>Place-based education characteristics</i>			
Characteristic	Implementer	Partial Implementer	Non-implementer
Local context	Yes	Yes	Yes
Experiential	Yes	Yes	Yes
Collaborate with local experts	Yes	Yes	Yes
Interdisciplinary	Yes	No	No
Civic engagement	Yes	No	No

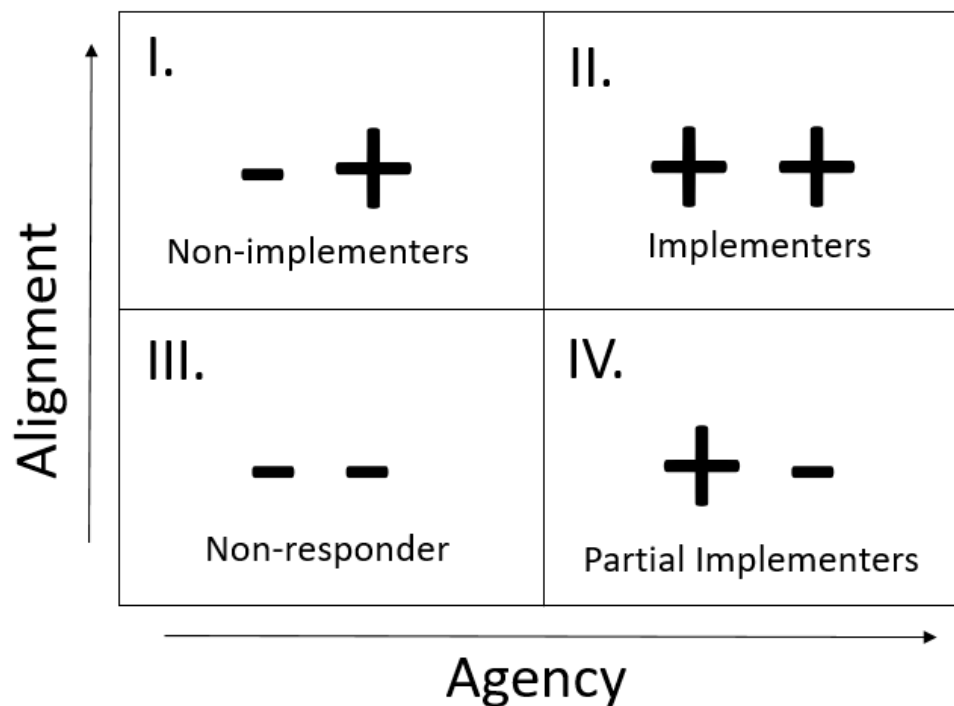


Figure 3.1. Model for Curriculum Implementation. Alignment is represented on the y-axis and agency on the x-axis and presence (+) and absence (-) of these constructs is indicated. In quadrant II, teachers were implementers of the PBE curriculum. In quadrant IV, teachers were partial implementers and demonstrated curricular agency but could not find curricular alignment. In quadrant I, non-implementers recognized curricular alignment but did not achieve agency. In quadrant III non-responders may have been interested in PBE curriculum but did not participate.

Implementing the curriculum involved adopting or adapting the provided materials. All participants were open to examining new PBE curriculum materials aligned with academic standards. Teachers believed the camera trap photographs would provide a valuable experience for students to investigate the local environment and wildlife across the city while introducing students to technologies used by wildlife ecologists. Teachers saw the lessons as an opportunity for students to analyze authentic data from a familiar context. Additionally, all participants felt they were supported by their administrators and peers, although to different degrees.

Implementers: Beth, Michelle, JoAnne

Implementers not only demonstrated agency to use PBE in their classroom, they

recognized the alignment with what they were expected to teach (standards) and how (class structure). All three teachers expressed comfort with taking risks and embracing PBE as a part of how all science is taught. They all had had (iterative) experience being innovative without fear of unknown outcomes. For example, Michelle chose to use her school's location next to a river to teach students scientific observation techniques and as a location for the school's camera trap. Based on positive feedback from students, she expanded her use of the local environment throughout the school year and supported the development of a school-wide "River Week." Implementers described future benefits (projective) for themselves and their students by learning how to ask and investigate questions that cannot be answered within the time frame of one class period or curriculum unit. They also recognized the potential (projective) benefits of reaching out to the community.

Beth was motivated to implement PBE strategies using the data based on prior experience with camera traps both at a previous school and on family property; she saw the potential in using authentic data to help her students learn ecology. Hence, she achieved curricular agency by recalling past experiences, informing her current decisions, with intentions about future implementations.

"My family now is very into the cameras too... And now for Mother's Day we're putting a couple in my grandma's [farm] ...and she lives right by the river, so we know she gets deer and coyotes and turkeys and we've got a couple really good paths, so we're gonna set up a couple cameras to see what we can see."

Past experiences at successfully using camera trap technology allowed Beth to manage uncertainty that arises with using an open-ended curriculum and demonstrating the ability to reflect iteratively on past decisions. Additionally, during one observation and interview session,

Beth encouraged students to wonder about the collected camera data from cameras placed near the school and from former school cameras and develop questions that future camera data may help answer. Reflecting on the past, she demonstrated curricular agency in the present. She was aware of the (projective) potential future benefits for students as they considered bigger PBE questions together.

“... I said this is being used for actual research purposes, guys, so you can start making a difference now, and if you're really into this that can be a job path for you. I think it's helping them have a broader view of the impacts that they could be having on the place [her emphasis] where they're living.”

Although Beth did not indicate how her students could be civically engaged, she continued to reference phrases, such as “*do stuff in real life*” throughout her interviews and classroom instruction. As an example of how the camera trap data could be used for research purposes, Beth referenced honors thesis projects being conducted by undergraduate students using the camera locations and picture data. Similarly, Michelle believed that experience collecting scientific data can help students become better scientists and understand how data can be used to manage natural areas. They both continually referenced the past, the present, and the future as they made curricular decisions about PBE. As a past participant in Research Experience for Teacher programs in Africa and Alaska (the northernmost US state), Michelle knows that...

“...This is what I did when I was doing my research and here's my results and data tables and logbooks, and I want them to see that this is what scientists do.”

Here, Michelle illustrates her strong belief in experiential science education. Michelle went on to describe her approach to teaching science mixed with her own understanding of the goals of PBE while teaching about the environment. “*I’m a firm believer in getting kids outside*

doing field research...it's how science works – learning, reflecting, asking new questions...part of it for our kids is getting outside and realizing what's out there and how it's our responsibility to take care of the environment.”

Furthermore, Michelle explained the importance of teaching her students skills to be active community members and understanding their local environment. She referenced not only the curricular approach that her school followed (IB curriculum focuses on developing critical thinking skills while exploring issues from a global perspective; Tarc, 2009), but also the belief that only when students experience their environment are they aware of and concerned about environmental issues. Subsequent observations of Michelle's classroom took place at the river within walking distance of the school and in a local state park where students took part in activities to learn about the local environment and participate in a project to control non-native plant life. As she shared her thoughts about PBE, she spoke about connecting present experiences with future dispositions of her students, reflecting her own perceptions about her experiences as a teacher.

“...I feel if we want to keep our kids civically engaged in their community and their environment, they need to know what it is and they need to care about it...if we can get kids outside and caring about their environment and becoming educated about their environment so when they see things in the news and they hear things, they're aware of what that means.”

As a teacher who was originally stifled by the camera location barrier in the first year of the project, JoAnne was motivated to use camera trap data and used the professional development workshops as an opportunity to collaborate with peers in the

district by engaging in conversations with Michelle and Roger about their experiences using the photographic data. In the second year of the camera trap program, JoAnn moved the camera to a different location. She was able to overcome initial personal (knowing how to collect the data) and structural (logistics of asking students to collect the data) barriers of using a new technology, demonstrating how she achieved agency. She referenced the past and a perceived barrier, and then shared how she overcame the obstacle in the present. In her second year, she demonstrated confidence and enthusiasm in the data and shared this with her students.

“The last time I looked at the data, the kids were all working on something and I was just flipping through [wildlife pictures] and I was like ‘oh guys look at this’ and showed a couple of them, it sparked a little something in there, I think it’s easy to spark kids interest in it, because it’s a wildlife camera.”

This sparked the design of an integrated science and math lesson using the camera data from three schools to examine environmental factors and graph data on frequency of occurrences of different organisms. She then asked her students to draw conclusions about data collected from a single camera compared to those from multiple cameras. She designed an open assessment for which students designed their own ecosystem which she was excited to explain:

“We had podcasts, skits, built dioramas, and models [of ecosystems]. Like I had a girl... she did a Russian nesting doll, and on the outside, the biggest thing was the tertiary consumer, and the secondary consumer was inside that, and she had made clay models of each of them, and they were totally made up, like this [organism] has fangs and this one digs into the ground to do something, it was so,

so creative”

JoAnne did not compromise her expectations of locally-relevant ecosystem content knowledge, though, as she continued her description of one of her students.

“...But she still showed that she knew that there was a flow of energy and a cycle of matter, but the way she did it was so cool. And she was the only one who included the sun, ... the sun was the middle of her Russian nesting doll...that one blew me away!”

By taking the risk to let students demonstrate learning in a way that allowed them to be creative, JoAnn sparked her students’ creativity. Furthermore, JoAnne garnered support from her administrator, further providing a context in which she could achieve and demonstrate curricular agency to adopt and adapt PBE curriculum when she reflected on the value of sharing successes.

“When I was telling our principal about this project, I was so excited, like they're gonna invent ecosystems and they're gonna show it however they want, and he's like, that sounds really cool, because he's never said no....So that was kinda scary for me, but as long as I can see what you (the student) knows about ecosystems., We still had a rubric, we still had success criteria’

Because implementers recognized the alignment with instructional and curricular goals and demonstrated agency to not only adopt but to adapt PBE curricula, they were able to fully embrace all five components of PBE using the camera trap curriculum. Their students studied local wildlife, collaborated with other teachers and wildlife experts, participated in experiential lessons, made interdisciplinary connections, and included community engagement experiences. A culminating event after the PBE unit was to

create public announcement posters that were displayed at the local shopping mall to educate the public about the wildlife living in the community (Fig. 3.2).



Figure 3.2. Community Civic Engagement. An example of a place-based education civic engagement outcome is participation in a community art exhibit at the local shopping mall where students are able to visually demonstrate the co-existence of humans and wildlife.

Partial Implementers: Roger, Anna, Teresa

Teachers who were partial implementers achieved agency to design and implement their own curriculum for their classroom but, due to misalignments with curriculum or class structure, they did not fully implement PBE (Fig. 1, quadrant IV). They demonstrated comfort with using new inquiry curricula and expressed personal connections or curiosity about the natural environment. Partial implementers asked students to collect data from camera traps and

discussed the wildlife in the area. The data were used in the classroom but not in ways that extended beyond the school environment. None of these teachers referenced past experiences that would have influenced their perception of either adopting new curricula or engaging in PBE professional development (Priestley et al., 2012). They did not demonstrate that they were reflexive of their past teaching experiences but did consider action for future experiences (Ryan & Bourke, 2013), hindering their abilities to achieve agency. We found that only the full implementers demonstrated both alignment and agency, whereas in the “partial implementer” group, alignment was missing. Although Roger demonstrated agency, the academic standards that drove his curriculum did not include those related to ecology. He chose to use the camera data as a way to engage students during an Extended Learning Period.

“Generally, we go out there [to the camera] and we explore the area then because here we are blessed with more property than anywhere else in the district, and we’re also in that urban rural interface with a wildlife corridor.”

Roger capitalized on using the location of the school to prompt his students to observe the environmental context around their school. He wanted his students to feel a connection to their community yet could not fully implement PBE using the camera trap data since it did not meet his curricular goals, even though he was comfortable with the camera trap technology.

Teresa described her participation in the camera trap project as “*a great opportunity for me so I’ve been able to revise my [ecology] curriculum and [PBE] approach without waiting a year, so it’s a great experience for me as a new teacher.*” She saw the potential in using photographic data to teach students about local issues and the nature of science. “*I have huge dreams for this database and the power that could come from the data. I would want to make it a regular routine of checking the camera because it’s good scientific practice of following that*

protocol, collecting that data in the same way, standardizing information and procedures.”

She discussed her own feelings about sustainability in her work. *“I think creating that personal connection with [students] ...that's the key. Conservation action is about creating that personal connection.”* Teresa referenced her graduate program in Advanced Science Inquiry. She used her curricular agency to draw on her experiences to modify curriculum in ways that enhanced learning for her current students with goals of increasing their future environmental literacy.

She spoke about projective potential, even though the PBE lessons did not align with her teaching context. The barrier preventing Teresa from being a full implementer of PBE was the class structure at her school. The class she taught was an Environmental Science elective that met for 50 minutes once a week. In the middle of the spring semester, Teresa was informed that the school would not be offering Environmental Science the following year. In spite of the personal drive to implement PBE in her classroom, lack of contact time with students only allowed for partial implementation.

Similar to Teresa, Anna was in *“a very unique school [in RSD], we’re a hybrid school, which means that our students sometimes work online and sometimes they’re here on campus doing traditional classes.”* Being the only middle school science teacher at her school, Anna chose to design course curriculum for her classroom drawing on

“...collaboration with people outside our school...I am the middle school science department here. It’s great we have connections to other schools to find out what they’re doing as well. But primarily I look at the [ecology academic] standards, what the students need to learn at the age they’re at, and design the [PBE] curriculum around that.”

She was able to *“look at what my students have done online and change what I want to do in a*

live class, because either they didn't get it, or they did get it." Also, Anna took advantage of the school building's location to implement the urban wildlife PBE lessons.

"Our location, it's great. It's exciting that we have [a creek] right here...And this camera study will be a perfect way to get the kids down and engaged, and the fact that we have a wildlife corridor blocks from our school but we're right on the major busy street in this city, so I thought it was a great way to utilize our neighborhood."

Although Anna has the resources and mindset to be an implementer and spoke in projective terms about how the curriculum could impact learners' understanding of urban ecosystems, she was unable to fully implement the PBE curriculum because of structural context - her students study in hybrid courses. First, *"some people really struggle with the online if you don't have time management, or if you don't have a learning coach, an adult who can help you, it can be a struggle to complete that independently."* Second, the student population *"fluctuates a lot. We get transfers mid-semester, both ways [in and out]."* This results in having to review material rather than going deeper or moving forward with content.

Non-implementers: Megan, Jessica, Melissa, Carla, CiCi

Non-implementers perceived the alignment of the PBE camera trap project with their curriculum and class structure but lacked agency to use the data in their classroom. Some of the non-implementers (Megan and Jessica) demonstrated alignment but no agency. They did not draw on experiences that they created for themselves to be reflective and reflexive. Although they attended multiple professional development workshops designed to provide collaboration time with local urban wildlife/camera trap experts, curriculum design experts, and peers, they still failed to be active implementers.

Both Megan and Jessica placed value on the experience using data collected by the

cameras and the potential it could provide students to connect science learning with their local natural area. Megan felt students would be able to make “*actual real-world connections*” while Jessica envisioned “*so many different ways that we can use the data and pictures.*” These non-implementers expressed personal interest in the project and curriculum yet discussed the use of it as something happening in the future. “*I definitely want to be doing that next year,*” Megan said. Similarly, Jessica explained: “*Last semester I was really involved with writing (camera trap) curriculum and sadly because I was writing it and spending my time on that, I wasn’t using the curriculum as much in my science class last semester.*”

Megan, who wanted to use the camera traps and data as part of an after-school ecology club, experienced difficulty navigating the procedures for taking students off school property, “*I’m still kinda hazy what the rules are with the permission slips.*” With a constantly changing group of students, she was unsure how to ensure all students had permission to go outside on various dates throughout the year. These non-implementers saw the potential in using the data as a way to engage students in learning about the local environment but did not have the agency to implement its use in the classroom at the time of the study, although neither described administrators as barriers.

The second group of non-implementers (Melissa, Carla, and Cici) did not use the wildlife camera trap project professional development workshops or curriculum. Although the idea of using local photographic data to teach about ecology interested them, they were not willing to put the effort into overcoming perceived barriers with technology, data management, or organizing a large number of students to visit the camera trap to change their current curriculum plans.

Melissa could see the potential of having locally relevant data, as she described below:

“I think it’d be really great to have access to that authentic data, so instead of teaching ecology from a formulaic perspective, that this animal eats that and such and such, that you could actually have some real numbers...”

However, she was unsure of how to get the large number of students she and her science grade-level peers shared to visit the camera site, which they never determined.

“Field trips are out for us... we’re so large and the bus schedules are so tight. We would have to do a field trip between 9:30am and 1:30pm. We have about 380 students. And every teacher wants time with their students, so missing out on content, so it’s really transportation limits us to getting off campus.”

Interestingly, Melissa did not consider collecting the data on her own (retrieving the memory card from the camera trap) or responding to email messages to develop a collaboration with community members (e.g., university wildlife student) to help, so her students could analyze data in the classroom. CiCi had seen another teacher partner with a local expert on a previous camera trap project in a location more than 30 minutes-drive away from the school. She implied that the effort of collaborating with a community member was too time and energy consuming, and therefore, not worth it for her.

“She was working with another guy [who] had his own organization...[and] he was helping with that whole thing. ... But that was crazy, she was always driving down there and doing all that stuff..., it was too much, too teacher intensive and not localized enough.”

It was not clear what would be more “localized” in CiCi’s opinion; she did not elaborate. It was clear that she was not interested in the effort of collecting camera trap data, whether it was by herself or with a community partner.

Meanwhile, Carla was curious about how to manage large amounts of data. *“One of the*

questions I had for the photos in the Dropbox: if I had 1000 pictures, how do I upload all of them?" Here, Carla could not imagine how to organize a large data set, even though it would represent authentic, locally-relevant data for her students to analyze. Carla decided to not participate in the project, demonstrating she was unable to reflect on past experiences to determine how to overcome perceived barriers. Although Carla was a teacher who might consider using camera trap PBE lessons, if she had more professional development on data management and analysis. She did not express concerns about the technological aspects per se.

Non-responsive

Non-responsive teachers did not participate in professional development opportunities and never replied to invitations to be interviewed to explain their perspective and perceptions.

Discussion

Although there is potential to increase students' environmental and civic literacy through the use of place-based education curricula, we found that middle school teachers need support to help them identify the alignment of lessons with their professional expectations as well as agency to adapt lessons so they are meaningful for their students. Teachers who perceived a curricular alignment and demonstrated curricular agency implemented the PBE curriculum presented to them (Table 1). They were able to address academic standards using local examples with support from local wildlife experts, incorporate an interdisciplinary approach, and investigate potential avenues for civic engagement. Partial and non-implementers either perceived a misalignment or lacked agency to integrate the camera trap curriculum in their ecology units or in other content areas at deep levels (e.g., promoting civic involvement). Instead, these teachers focused primarily on ecological information transfer, while the implementing teachers interconnected knowledge across content areas and encouraged students to take action in the community using

evidence they collected about urban wildlife.

PBE is designed to increase K-12 students' environmental literacy skills, while encouraging them to be active community members as they develop better understanding of local social and biophysical ecosystems (McInerney et al., 2011; Sobel, 2004). This is particularly relevant because people demonstrate a range of conceptions of how humans are a part of and affect ecosystems (Casper & Balgopal, 2018). However, teachers need to feel prepared to support their students if they are to implement a PBE curriculum. The teachers in our study demonstrated a range of involvement in PBE instruction based on their ability to perceive how to integrate the lessons into their existing curricular framework and their experience in doing so. Because teachers who can act purposefully within their work environment and continue to learn from past perceived barriers demonstrate agency, we conclude that this attribute may explain when teachers choose to implement PBE lessons or not, since an interest in environmental education is not enough to determine which teachers will adopt environmental education curricula (Spence et al., 2013).

Successful curriculum propagation includes designers understanding potential adopters (teachers) and their instructional system (school, district, and academic standards), as well as designers engaging with potential users for input prior to presenting a finished curriculum (Stanford et al., 2017). Because the first had previously been employed by RSD, she held an initial understanding of district structures to navigate in order for teachers to use a new curriculum. For PBE curricular reform to occur, teachers need to feel comfortable and willing to adapt the curriculum for their educational context (Henderson et al., 2015; Roehrig & Kruse, 2005). Yet, preceding this comfort level is having had the experience and support to modify curricula, demonstrating curricular agency, (Priestley et al., 2012; Tao & Gao, 2017). When

teachers are able to draw on their curricular agency to meet the needs of students, their use of adapted curricular resources are more likely to be sustained (, 2020; Khatri et al., 2016). For example, at one teacher professional development workshop, JoAnn, who had not used any of the curriculum or photographs at the time, asked “what do you want me to do?” The reply from the workshop facilitator was an invitation to design lessons that are meaningful to her students using wildlife data to teach about urban ecological systems. After conferring with other teachers, JoAnn eventually designed an integrated math and science project that she continues to use. This study presents a model, informed by teacher agency that describes when teachers adopt, adapt, or do not use PBE lessons.

To advance environmental literacy in the classroom teachers need to help students make the connection between social and ecological systems and between ecological and community well-being. Educators need practical instructional strategies to bring these connections to fruition to help their students become environmentally literate and engaged citizens. For example, in this study, teachers who implemented PBE lessons assisted their students in engaging and educating their community about urban wildlife through a poster presentation (“Communities, Cameras and Conservation”) in the local shopping mall. Being environmentally literate requires making decisions using ecological knowledge, while demonstrating an awareness of the consequences of one’s decisions and other human actions on the environment (Jordan et al, 2009, et al., 2009). Environmental education curricula are often designed to teach learners how natural environments function and the way human beings can manage their interactions and dependence on ecosystems in a sustainable manner (Hungerford et al. 1980; Tilbury, 1995). However, these curricula do not always include strategies for teachers to help their students also become civically engaged. As teachers and students use the local contexts to excite and engage their students, they can ask and

answer questions about their local community, seeding the possibility of being involved in local environmental actions (Schusler & Krasney, 2008).

Implications

Because civic engagement is a goal of PBE, it behooves curriculum developers and teacher educators to support teachers as they explore how to involve their students in making decisions about their actions. PBE lessons are often interdisciplinary since they integrate socio-economic issues, explore engineering solutions to issues, and require that students communicate their solutions to community members (Henry-Stone, 2010). Hence, PBE lessons, because they center on small group work and problem-solving, can help students develop their science argumentation and communication skills (e.g., McNeill et al., 2013). Yet, teacher educators must acknowledge that beliefs and practices about PBE may not always be aligned (Woodbury & Gess-Newsome, 2002). Teachers play an important role in addressing local and global environmental issues by supporting the development of environmental literacy of their students. Teachers' concerns about new curricula include the alignment with academic standards and how the curriculum can be modified/implemented in their classrooms. To address this need, we call on teacher educators to encourage teachers to recount past experiences when they have tried adapting and implementing new curricula and ask them to identify how they overcame perceived barriers (Biesta et al., 2015). Teacher educators should also consider the extent to which teachers want to implement new curriculum. Teachers are often encouraged to design or modify learning experiences for their students, yet they may not be dissatisfied with the current curriculum. To encourage teachers to adopt PBE curricula, they need to be given opportunities to be constructive participants in their own professional growth that can feed back into their classroom (Davis, 2003). For example, teacher educators should engage in dialogue with teachers about what skills

and knowledge they believe they need to help them implement PBE lessons as well as, understand the alignment of the curricula with school policies and practices and individual teacher agency (Fig. 1). Finally, some teachers expressed concerns about overcoming technological issues (using camera trap technology or managing large photographic data sets). PBE teacher educators should acknowledge that teachers are not likely to use a curriculum that requires them to spend time trouble-shooting technological or methodological issues without support. Although, in our study, community partners expressed willingness to support teachers, we posit that a more active approach may be needed. For example, if community partners share how they have helped other educators, new adopters may be more receptive to collaborating. In addition, community partners may need to reach out actively to teachers, rather than waiting for teachers to contact them, to demonstrate their willingness to support teachers. Because most academic standards in the U.S. are focused on classroom experiences, teachers may be interested but overwhelmed with how to teach environmental lessons in community-based ways. As our study demonstrates, engaged teachers and students can find creative ways to share their new knowledge with their communities.

Literature cited

- Addy, T. M., & Blanchard, M. R. (2010). The problem with reform from the bottom up: Instructional practices and teacher beliefs of graduate teaching assistants following a reform-minded university teacher certificate programme. *International Journal of Science Education*, 32(8), 1045-1071.
- Ardoin, N. M. (2006). Toward an interdisciplinary understanding of place: Lessons for environmental education. *Canadian Journal of Environmental Education (CJEE)*, 11(1), 112-126.
- Balgopal, M. M., & Wallace, A. M. (2009). Decisions and dilemmas: Using writing to learn activities to increase ecological literacy. *The Journal of Environmental Education*, 40(3), 13-26.

- Balgopal, M. M. (2020). STEM teacher agency: A case study of initiating and implementing curricular reform. *Science Education*, 104(4), 762-785.
- Bandura, A. (1997). Self-efficacy: The exercise of control. Macmillan.
- Biesta, G., & Tedder, M. (2007). Agency and learning in the lifecourse: Towards an ecological perspective. *Studies in the Education of Adults*, 39(2), 132–149.
- Biesta, G., Priestley, M., & Robinson, S. (2015). The role of beliefs in teacher agency. *Teachers and Teaching*, 21(6), 624-640.
- Bowers, C. A. (2008). Why a critical pedagogy of place is an oxymoron. *Environmental Education Research*, 14(3), 325-335.
- Casper, A. M. A., & Balgopal, M. M. (2018). Conceptual change in natural resource management students' ecological literacy. *Environmental Education Research*, 24(8), 1159-1176.
- Charmaz, K. (2005). Grounded Theory in the 21st Century: Applications for Advancing Social Justice Standards. In N. K. Denzin & Y. S. Lincoln (Eds.), *The SAGE Handbook of Qualitative Research* (2nd ed., pp. 507–537). Thousand Oaks: Sage Publication.
- Charmaz, K. (2020). “With constructivist grounded theory you can’t hide”: Social justice research and critical inquiry in the public sphere. *Qualitative Inquiry*, 26(2), 165-176.
- Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.
- Creswell, J. W., & Poth, C. N. (2016). *Qualitative inquiry and research design: Choosing among five approaches*. Sage publications.
- Cruz, A. R., Selby, S. T., & Durham, W. H. (2018). Place-based education for environmental behavior: A ‘funds of knowledge and social capital approach. *Environmental Education Research*, 24(5), 627-647.
- Dale, R. G., Powell, R. B., Stern, M. J., & Garst, B. A. (2020). Influence of the natural setting on environmental education outcomes. *Environmental Education Research*, 1-19.
- Davis, K. S. (2003). “Change is hard”: What science teachers are telling us about reform and teacher learning of innovative practices. *Science Education*, 87(1), 3-30.
- Emirbayer, M., & Mische, A. (1998). What is agency?. *American Journal of Sociology*, 103(4), 962-1023.

- Ernst, J., & Monroe, M. (2004). The effects of environment-based education on students' critical thinking skills and disposition toward critical thinking. *Environmental Education Research*, 10(4), 507-522.
- Flanagan, C., & Galloway, E. (2014). Adolescents' theories of the commons. In *Advances in Child Development and Behavior* (Vol. 46, pp. 33-55). JAI.
- Flanagan, C. A., Galloway, E., Pykett, A. A., & Smallwood, M. (2019). The Environmental Commons in Urban Communities: The Potential of Place-Based Education. *Frontiers in Psychology*, 10, 226.
- Forman, R. T. (2014). *Urban ecology: science of cities*. Cambridge University Press.
- Furtak, E. M. (2012). Linking a learning progression for natural selection to teachers' enactment of formative assessment. *Journal of Research in Science Teaching*, 49(9), 1181-1210.
- Galloway, E., Marckini-Polk, L., Schroeder, B., & Flanagan, C. (2016). Place-based stewardship education: Nurturing aspirations to protect the rural commons. *Peabody Journal of Education*, 91(2), 155-175.
- Greenwood, D. A. (2008). A critical pedagogy of place: From gridlock to parallax. *Environmental Education Research*, 14(3), 336-348.
- Gruenewald, D. A. (2003a). Foundations of place: A multidisciplinary framework for place-conscious education. *American Educational Research Journal*, 40(3), 619-654.
- Gruenewald, D. A. (2003b). The best of both worlds: A critical pedagogy of place. *Educational Researcher*, 32(4), 3-12.
- Gruenewald, D. A., & Smith, G. A. (2008). Introduction: Making room for the local. *Place-based Education in the Global Age*, xiii-xxiii.
- Gruenewald, D. A., & Smith, G. A. (Eds.). (2014). *Place-based education in the global age: Local diversity*. Routledge.
- Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. *Handbook of qualitative research*, 2(163-194), 105.
- Henderson, C. Cole, R., Froyd, J., Friedrichsen, D.G., Khatri, R., & Stanford, C. (2015). Designing educational innovations for sustained adoption. Increase the Impact Team.
- Henry-Stone, L. (2010). Cultivating sustainability pedagogy through participatory action research in interior Alaska. *Journal of Sustainability Education*, 1

- Hungerford, H., Peyton, R. B., & Wilke, R. J. (1980). Goals for curriculum development in environmental education. *The Journal of Environmental Education*, 11(3), 42-47.
- Jordan, R., Singer, F., Vaughan, J., & Berkowitz, A. (2009). What should every citizen know about ecology? *Frontiers in Ecology and the Environment*, 7(9), 495-500
- Kays, R. (2016). *Candid Creatures: How Camera Traps Reveal the Mysteries of Nature*. The Johns Hopkins University Press, Baltimore, Maryland.
- Knapp, C. E. (2005). The "I-thou" relationship, place-based education, and Aldo Leopold. *The Journal of Experiential Education*, 27(3), 277.
- Knapp, C. E. (1985). Using Valuing and Inquiry Skills in Environmental Education.
- Khatri, R., Henderson, C., Cole, R., Froyd, J. E., Friedrichsen, D., & Stanford, C. (2016). Designing for sustained adoption: A model of developing educational innovations for successful propagation. *Physical Review Physics Education Research*, 12(1), 010112.
- Kudryavtsev, A., Krasny, M. E., & Stedman, R. C. (2012). The impact of environmental education on sense of place among urban youth. *Ecosphere*, 3(4), 1-15.
- Kudryavtsev, A., Stedman, R. C., & Krasny, M. E. (2012). Sense of place in environmental education. *Environmental Education Research*, 18(2), 229-250.
- Lee, C. J. G. (2012). Reconsidering constructivism in qualitative research. *Educational Philosophy and Theory*, 44(4), 403-412.
- Linnemanstons, K. A., & Jordan, C. M. (2017). Learning through place: Evaluation of a professional development program for understanding the impact of place-based education and teacher continuing education needs. *Journal of Sustainability Education*, 12, 1-25.
- McInerney, P., Smyth, J., & Down, B. (2011). 'Coming to a place near you?' The politics and possibilities of a critical pedagogy of place-based education. *Asia-Pacific Journal of Teacher Education*, 39(1), 3-16.
- McNeill, K. L., Pimentel, D. S., & Strauss, E. G. (2013). The impact of high school science teachers' beliefs, curricular enactments and experience on student learning during an inquiry-based urban ecology curriculum. *International Journal of Science Education*, 35(15), 2608-2644.
- Miller, D., & Twum, S. (2017). The experiences of selected teachers in implementing place-based education. *in education*, 23(1), 92-108.
- Nagel, N. G. (1996). *Learning through Real-World Problem Solving: The Power of Integrative Teaching*. Corwin Press, Inc., 2455 Teller Road, Thousand Oaks, CA

- NGSS Lead States. (2013). Next generation science standards: For states, by states. Washington, DC: The National Academies Press.
- Nugent, J. (2017). Citizen science: Where the wildlife are. *Science Scope*.
- O'Connell A.F., J. D. Nichols, and K. U. Karanth. (2011). *Camera traps in animal ecology: methods and analyses*. Springer, New York City, NY.
- Pitman, S. D., Daniels, C. B., & Sutton, P. C. (2018). Ecological literacy and socio-demographics: who are the most eco-literate in our community, and why? *International Journal of Sustainable Development & World Ecology*, 25(1), 9-22.
- Priestley, M., Edwards, R., Priestley, A., & Miller, K. (2012). Teacher agency in curriculum making: Agents of change and spaces for manoeuvre. *Curriculum Inquiry*, 42(2), 191-214.
- Roberts, D. A., & Bybee, R. W. (2014). Scientific literacy, science literacy, and science education. In *Handbook of Research on Science Education, Volume II* (pp. 559-572). Routledge.
- Roehrig, G. H., & Kruse, R. A. (2005). The role of teachers' beliefs and knowledge in the adoption of a Reform-Based curriculum. *School Science and Mathematics*, 105(8), 412-422.
- Ryan, M., & Bourke, T. (2013). The teacher as reflexive professional: Making visible the excluded discourse in teacher standards. *Discourse: Studies in the Cultural Politics of Education*, 34(3), 411-423.
- Schusler, T. M., & Krasny, M. E. (2008). Youth participation in local environmental action: An avenue for science and civic learning?. In *Participation and Learning* (pp. 268-284). Springer, Dordrecht.
- Semken, S., & Freeman, C. B. (2008). Sense of place in the practice and assessment of place-based science teaching. *Science Education*, 92(6), 1042-1057.
- Smith, G. A. (2002). Place-based education: Learning to be where we are. *Phi Delta Kappan*, 83(8), 584-594.
- Smith, G. A. (2007). Place-based education: Breaking through the constraining regularities of public school. *Environmental Education Research*, 13(2), 189-207.
- Smith, G. A., & Sobel, D. (2010). Bring it on home. *Educational Leadership*, 68(1), 38-43.
- Sobel, D. (2004). Place-based education: Connecting classroom and community. *Nature and Listening*, 4, 1-7.

- Soulsbury, C. D., & White, P. C. (2016). Human–wildlife interactions in urban areas: A review of conflicts, benefits and opportunities. *Wildlife Research*, 42(7), 541-553.
- Spence, E., Wright, T., & Castleden, H. (2013). Present, absent, or tardy? A study of the barriers, bridges, and beliefs concerning environmental education among a cohort of sixth grade teachers in Nova Scotia. *Applied Environmental Education & Communication*, 12(3), 197-206.
- Stanford, C., Cole, R., Froyd, J., Henderson, C., Friedrichsen, D., & Khatri, R. (2017). Analysis of propagation plans in NSF-funded education development projects. *Journal of Science Education and Technology*, 26(4), 418-437.
- Sullivan, P. B., Buckle, A., Nicky, G., & Atkinson, S. H. (2012). Peer observation of teaching as a faculty development tool. *BMC Medical Education*, 12(1), 1-6.
- Tao, J., & Gao, X. (2017). Teacher agency and identity commitment in curricular reform. *Teaching and Teacher Education*, 63, 346-355.
- Tarc, P. (2009). *Global dreams, enduring tensions: International Baccalaureate in a changing world*. Peter Lang.
- Tilbury, D. (1995). Environmental education for sustainability: Defining the new focus of environmental education in the 1990s. *Environmental Education Research*, 1(2), 195-212.
- Wiggins, G. P., & McTighe, J. (2011). *The understanding by design guide to creating high-quality units*. ASCD.
- Woodbury, S. & Gess-Newsome, J. (2002). Overcoming the paradox of change without difference: A model of change in the arena of fundamental school reform. *Educational Policy*, 16(5), 763-782.
- Woodhouse, J. L., & Knapp, C. E. (2000). *Place-Based Curriculum and Instruction: Outdoor and Environmental Education Approaches*. ERIC Digest.

CHAPTER 4

WHAT KEEPS RURAL SCIENCE TEACHERS IN PLACE?: TEACHER PROFESSIONAL RESILIENCE

The U.S. is experiencing a critical shortage of science teachers (Sutcher et al., 2019). Some schools are affected more than others: 45% of all teacher turnover occurs in just 25% of public schools, especially those located in rural or urban districts lacking financial and material resources. Moreover, there is a marked “shuffling” of teachers from financially disadvantaged rural and urban schools to wealthier ones (Achinstein et al., 2010; Showalter et al., 2015). When teachers move from one school district to another, it affects both students, who experience disrupted school stability, and teachers, whose collegiality, collaboration, and institutional knowledge may suffer (Ronfelt et al., 2013; Watlington et al., 2010). Rural schools are particularly vulnerable to these impacts (Goldring et al., 2013); with a smaller staff, the impact of the loss of one teacher is greater compared schools with a larger staff. In addition, rural teachers are often required to teach outside of their field of expertise, prompting frustrated teachers to leave schools (Dupriez et al., 2016; Nguyen, 2020). Rural teachers, who may be isolated from their broader professional community, must draw on their personal and social networks as they respond to changing educational expectations and social norms.

Faced with managing multiple expectations and resources, teachers respond by either staying, moving, or leaving the school level system (DeAngelis & Presley, 2010). *Stayers* remain in the same role at the same school (e.g., as a classroom teacher across years), *movers* either move to a new role in the same school (e.g., moves from the role of classroom teacher to administrator) or same role at a new school (e.g., becomes a classroom teacher in a new

location), and *leavers* move out of their role and the education system altogether (Luekens et al., 2004). Resilient teachers are defined as stayers who not only meet the daily challenges of teaching but also thrive by taking actions to support persistence in rural school classrooms (Day & Gu, 2013). Understanding what vulnerabilities and adaptations affect rural science teachers' decisions to remain or leave teaching is essential in supporting rural science education. Vulnerabilities are school structures that are sensitive to manipulation or change, such as schedules and class size; the adaptations are actions taken by teachers to manage their professional activities. Therefore, teacher educators and administrators must identify the variables that affect the vulnerabilities and adaptive actions teacher take to manage chronic disruptions, in order to help them increase their capacities for professional resilience.

In this paper, we studied rural teachers in an American western state and describe (1) their perceptions of their professional “vulnerabilities” and (2) their use of adaptive capacities to be professionally resilient (i.e., remaining in rural schools).

Conceptual Framework

Our study was informed by both systems theory and an integrated capital theory. Systems theory is an interdisciplinary study of systems as cohesive groups in interrelated, independent parts that can be natural or human-made (Folke, 2006). Although resilience and adaptive capacity are most often used to describe natural systems and how they respond to perturbations, we find the terms useful when examining social systems, like educational systems (Wright et al., 2019). Natural and social systems are complex and adaptive with system components linked through feedback mechanisms that display resilience or transformation in response to disturbances (Folke et al., 2003). Because systems exist and function on multiple scales of space, time, and organization, the model of adaptive capacity depicts the phases of natural systems as

they experience disturbance and recovery (Holling & Gunderson, 2002). System resilience, defined as the ability to recover from disturbance, is the key to enhancing a system's adaptive capacity (Folke et al., 2003).

All systems have vulnerabilities that expose them to disturbances. Educational systems are complex systems spanning national, regional, and local levels. Like other complex systems, they experience stability and change as a whole system, as well as at individual levels (Keshavarz et al., 2010). For example, changes at macro-system levels (e.g., new academic standards introduced at the state level) affect micro-system level dynamics (e.g., instructional resources used by teachers). In schools, vulnerabilities are structures and contexts that are subject to change (e.g., policies, economic growth, content expectations). When actors within systems are aware of the vulnerabilities, they can manage these (Berkes & Ross, 2016) and identify important and helpful capital that can increase their adaptive capacities (Liou & Canrinus, 2020).

Rural science teachers are situated as actors at the school level in this nested education system. Because teachers operate within systems, leveraging and investing capital shapes their capacity to act within the system. Although they may appear to have agency and control in their own classrooms, their educational choices are affected by their students and their families, their administrators and peers, the social community, and state and national policies dictating what and how they should teach science (Diamond, 2012).

Science teachers manage micro-level systems in their respective classrooms, and in doing so, may decide to draw on both bio-physical (e.g., monitoring local wildlife as part of a lesson) and socio-economic (e.g., visiting a local business to explore careers) resources. Teachers make decisions to balance external system expectations (e.g., expectations to meet academic standards and prepare students for mandated high stakes assessments) and internal expectations (e.g., what

capital they can leverage to make science socially relevant to their students; Virapongse et al., 2016). Sometimes, teachers feel that they must negotiate potentially conflicting expectations (e.g., teaching standards-based anthropogenic climate change when communities are unsupportive; Scheer, 2021). In other words, teachers work in complex systems drawing on different capital to meet professional, social, and personal expectations.

Liou and Canrinus (2020) classified capitals relevant to teachers as human (people's knowledge, skills, and experience), social (the emergent properties of relationships - like trust, expectations, and obligations), and emotional (investment in interpersonal relationships with anticipation of positive outcomes). Through social interactions with staff, students, and community members, teachers learn the cultural values of the school community members. Teachers must draw on and make use of available resources and capitals to feel professionally agentic. Professional networks provide opportunities for teachers to develop and invest in human, social, and emotional capitals. However, not all teachers believe they have access to different capital, and as result, their professional decisions are influenced by their beliefs about their personal contexts and support from their professional communities of practice (Gu & Day, 2013; Woodbury & Gess-Newsom, 2002). Communities of practice, including social networks, provide different resources and capital, as well as a sense of belonging, needed by teachers to feel professionally resilient (Çiftçi & Cin, 2018; Patton & Parker, 2017; Printy, 2008).

Here, we describe how rural science teachers perceived their professional and social communities and how these perceptions were related to their respective professional resilience and adaptive capacity. Our guiding research questions were: (1) *What adaptive strategies do rural science teachers use to develop professional resilience in a changing educational landscape?* and (2) *How do they use resources and capitals to become professionally resilient?*

Methodology

We conducted an instrumental case study analysis to explore the experiences of nine secondary science teachers in rural schools in [state] in the U.S. (Yin, 2009). Our objective was to examine the teachers' perceptions and describe patterns of those who exhibited adaptive capacity in rural school systems that experience high levels of teacher shortages. Instrumental case study methodology allows researchers to focus on a phenomenon with a bounded set of participants to better understand a broader social experience (Yin, 2009). In this study, therefore, describing how our participants exhibited professional resilience will allow us to continue exploring what may affect other rural science teachers' professional resilience.

Context and participants

We recruited secondary science teachers in the northeastern part of [state], where the economy is driven by agriculture and energy production. Teachers were contacted through our professional networks and proximity (within two-hours driving time from our institution). The science teachers' school districts were defined as rural according to the [state] Department of Education based on location (outlying city population 7,000-30,000, outlying town population 1,000-7,000, and remote population less than 1,000) and school district size (rural 1,000-6,500 student enrollment and small rural less than 1,000 student enrollment). Although this was a convenience sample, the teachers represented eight different schools in seven districts and five counties. Across the schools, there was variation in the number of students attending the school, percentage of students receiving free and reduced lunch, and grade level(s) taught by the teacher. Participants also varied with respect to their science teaching experience, ranging from a first-year teacher to teachers with over ten years' experience (Table 4.1).

Table 4.1. Rural Teacher Participant and School Information

Teacher	Years of Experience	Assignment	School Size	School Setting Classification
Stayers				
Ms. S	7	Grade 7	721	Outlying City, Rural
Mr. M	17	Middle and High School	127	Outlying City, Rural
Ms. W	4	Middle and High School	93	Remote, Small Rural
Mr. C	4	High School	557	Outlying Town, Rural
Ms. M	12	High School	267	Outlying Town, Small Rural
Mr. F	1	High School	267	Outlying Town, Small Rural
Movers				
Ms. F	12	High School	450	Outlying City, Rural
Mr. K		Middle and High School	93	Remote, Small Rural
Leavers				
Ms. Y	12	High School	318	Outlying Town, Rural

Data collection and sources

We used two sources of data collected over the 2017-18 and 2018-19 school years: interviews with the teacher and field notes (from observations and photographs of the school and community context). Semi-structured interviews lasting forty-five to sixty minutes were conducted in teachers' classrooms and focused on the context of the school within the rural community, although one interview occurred at a coffee shop in a nearby town. We photographed the school and classrooms, as well as the communities.

Data analysis

Data were coded using both inductive and deductive methods. Interviews were transcribed and initially analyzed using inductive thematic analysis to describe teachers' perceptions of their experiences as rural teachers (Braun & Clarke, 2006). Two independent raters, trained in the code book, co-coded 20% of the transcripts resulting in initial themes of "resources," "opportunities," and "relationships." The coders then individually coded the remaining transcripts reaching an 80% agreement of the codes. Disagreements were resolved through discussion among the research team until 100% coding consensus was achieved. Photographs of school buildings and the surrounding community were coded to provide context for participant descriptions of resources, opportunities, and relationships. Researcher field notes were used to triangulate the data. This first analysis of the interviews provided insight into the teachers' perceptions as individuals within their school systems. The deductive analysis process used an adaptive capacity lens to describe the vulnerabilities, adaptations, and resilience teachers felt they faced in the education system (Gallopini, 2006; Wright et al., 2019). Two independent raters coded the interviews until agreement was reached for 80% of the codes, and discussion between the raters resolved disagreements.

Trustworthiness was established by coding the data in two different ways, supporting the goals of this study first, to describe teachers' perceptions of their experiences and second, to describe how those experiences affected/were affected by the rural education system. Peer debriefing and inter-rater coding helped reduce analytic biases. Finally, for both rounds of analysis, teachers' curricular materials, observational notes, and photographs were used to triangulate our findings, further supporting final themes.

Findings

We found that rural science teachers who were **aware of their vulnerabilities** in both their personal and professional contexts could (1) manage vulnerabilities and (2) adapt to the disturbances. These teachers demonstrated professional resilience by accessing capitals that were professionally meaningful. All participants demonstrated a commitment to science education but varied in their commitment to remain in the science classroom or the community in which they were currently teaching. We defined professional resilience as teachers remaining in the classroom, while professional transformation was demonstrated when an individual left the classroom to take another professional position. We divided constructed cases based on differing levels of professional resilience: *stayers* ($n = 6$), *movers* ($n = 2$), and *professional transformers* ($n = 1$) (Table 1), sometimes referred to as *leavers*, although in our study, these teachers remained in the education system. Although the low sample size limits the generalizability of the results, the findings reveal salient aspects of the rural science teacher experience.

Stayers (adapters)

For rural teachers to remain in the same school, they must take adaptive actions to manage the vulnerabilities encountered in the education environment as well as draw on professional, social, and environmental capital (Coleman, 1988; Liou & Canrinus, 2020). *Stayers* all grew up in rural communities providing them with human capital (knowledge and skills) to navigate life in a rural environment, as well as rural community social (established relationships with others) capital. *Stayers* demonstrated intentionality to teach in a specific location. For Ms. M, the rural community is where she grew up and where her family chose to live. “*We’re pretty happy here. So, this is the closest we can be to family without essentially losing all those*

[retirement] benefits...We've put down roots here too...[we're] integrated into the community."

Ms. M drew on human and social capital to support her sense of belonging.

Similarly, Ms. S grew up in the rural community in which she now teaches. After leaving the community to study and enter her first career, she returned and built social connections in her childhood community. *"I am connected in the community now. And I grew up here, so I already had some of those connections...I am in the exact right position for my skills and my temperament and my personality."* The professional and social contexts in which Ms. S worked and lived supported her professional resilience. She drew on social resources built over her lifetime enabling her to establish a sense of belonging and desire to remain in her rural school. This experience was similar for Mr. F. After working with the Forest Service, Mr. F earned a teaching license. A product of a rural community, Mr. F changed professions, so he could leverage social capital in a familiar community. *"I do [feel connected to the community] which is odd to see since it's my 18th month. Such a short time that I've actually been in [town] and I do feel like I've anchored myself here."* Although Mr. F was "new" in his rural community, having grown up in a similar context allowed him to quickly adapt to both social and educational environments in a new location.

Stayers recognized the social role the school played in the community. Ms. W described the role of her school, *"We're definitely kinda the main hub [in the community]. A lot of parents and cousins and all that kind of stuff come to the [social events]."* The activities offered by the school and its physical location serve a crucial role for community social events. *"At our [game] concession stand, usually [community volunteers] make dinner every game night...it's definitely a backbone of the community."*

Interestingly, *stayers* were also career changers, those who became teachers with the intention of moving to and working in a small town. They acknowledged the economic vulnerabilities of living in rural communities and entering the teaching profession was a response to managing that vulnerability. Mr. M talked about taking advantage of an unexpected opportunity. “*So, I didn’t know I was actually going to go into education. My mom was a teacher. [I] grew up in the area.*” This connection to the community provided Mr. M with an established social network.

“And so, I went to [university], got my degree, um, actually I worked for a [university] extension office for 3 or 4 summers...but it obviously wasn’t steady. Then my mom was like, “You should just try subbing.” Coincidentally the teacher out here was pregnant, and she called me. “Hey, I hear you’re subbing. I know you have a science background and I’ll be honest; I’m probably not going to come back after I have my kid.” And so, I was like, “I’ll go out there. Give it my all.”

Mr. M recognized a professional opportunity within the rural community and made use of his social capital (e.g., connection to family and friends) to enter the education system. For 17 years, Mr. M taught at the same school then shifted to another school while continuing to live in the same rural community.

While these teachers possessed rural social capital, they also recognized the professional trade-offs of teaching in a rural school compared to larger, well-funded urban or suburban schools. Mr. C explained, “*I play that game of ‘I’ve got a supportive administration here, the students are generally pretty respectful and hardworking.’ [This district] pays pretty decently considering they’re a small school district.*” The benefits that Mr. C described are a trade-off to not living in the rural community where he teaches but rather in the closest urban center. “*I do*

not like the commute. I'll be the first one to tell you that I have a 35-minute drive going back home. But, again, I'm a one-off here. I get to do whatever I want." Mr. C was aware of both limitations and opportunities in his job. *"And so, having that kind of freedom because there's so little bureaucracy associated here, there's a certain appeal to being able to do what I want and not have to meet competing expectations here."* Hence, Mr. C was professionally resilient and willing to adapt to the challenges of rural schools.

For *stayers*, professional resilience was tied to social resilience. Not only did the teachers know how to adapt to changes in the school landscape, and draw on professional, social, and emotional capitals, they also adapted to the social landscape of the surrounding community. *Stayers* leveraged place in their professional activities. The environmental context for these science teachers was bound with social interactions in and outside of the professional setting. For example, *stayers* leveraged both knowledge and social capital to enrich the learning experiences of their students. Ms. M took her students to a nearby stream to measure turbidity and velocity when teaching an Earth system science class. Ms. W contacted wildlife biologists to help her set up camera traps around her school so students could monitor organisms for environmental science. Mr. M arranged a field trip to an agricultural company, so students could learn about job opportunities. With similar goals but a different approach, Ms. S brought local employees into the classroom, so her students could interact with community members with different science-related careers. Finally, both Mr. F and Mr. C found technology experts to help them design interactive lessons for their students related to robotics and geospatial analysis. In short, these *stayers* drew on resources in their local environment and accessed social capital.

Movers (adapters)

While *stayers* drew on both knowledge and social capitals to adapt to vulnerabilities in the school system, *movers* and *transformers* drew on only one capital. Moreover, *movers* and *transformers* did not identify as rural community members; they did not grow up in small towns and did not express wanting to work towards this identity. *Movers* demonstrated similar abilities to manage vulnerabilities in professional, personal, and social contexts, yet they chose to move from one rural school to another. *Movers* either looked for or took advantage of new professional opportunities.

For example, Mr. K had planned to leave his rural [state] at some point in time; “*I don’t anticipate staying there much longer.*” Although, Mr. K identified the positives of where he taught: “*I enjoy teaching where I’m at. I enjoy getting to know the students and teach multiple [grade levels] and the level of respect from the administration down as well as the parents of the students.*” In other words, Mr. K was not frustrated. In fact, he was drawn to teaching in a rural community because he felt it would provide job security while he was in the state and help him develop his resume by teaching multiple science content classes at multiple levels. He chose a rural school to help him advance professionally. “*I would like to be an administrator or a director position that would be a long-term goal.*”

Mr. K described both positive and negative variables he had to navigate in his professional environment. The rural school provided opportunities and barriers to career advancement. “*I want a school that’s a larger school where I will most likely be positioning myself working on my Ed.D. I want an opportunity to move up and there’s not many opportunities [here].*” In addition to acknowledging personal limitations (his plans for only remaining at a rural school for a short time) and the financial limitations (low

salary), Mr. K also expressed his intentions to remain socially distanced from the community. *“I tend to keep a very low profile at school partly because it's such a distance to drive from [suburban town where he lived] out to [rural community] that it's difficult for me to be solidly in the community.* Mr. K also shared other beliefs that distanced himself socially from the rural community:

“I have a lot of different [political ideologies] than a lot of the community. A lot of people find it difficult to understand that when I teach about evolution, I have to send an opt-out form to the parents.”

Mr. K was aware that his choice to remain socially separate from the rural community created professional barriers.

“I don't have any desire to be included [socially]. My social [community] is [elsewhere] and so I go and do the best job when I teach. I think it has hindered my ability to communicate with the students because I can't logistically spend time with students after school, I can't bond over the sports games.”

Although he could see the value of investing in human capital, Mr. K focused on his professional capital rather than social capital. Thus, he managed his own vulnerabilities as identified trade-offs. As a result of his choices, Mr. K felt *“accepted by the community but not a part of the community.”*

Another mover, Ms. F was intentional in her choice to work in rural communities and recognized the vulnerabilities and opportunities of rural schools. *“When I decided I wanted to go back to teaching ... I looked at a place [in rural community] and thought, ‘Hmm, the kids out here need a good science teacher too.’”* Ms. F described an economic advantage (affordable housing) of living in a rural community. Ms. F did not express intentions to leave her school; yet

she indicated that if the right circumstances occurred, she would be willing to relocate. Ms. F chose to live in an affordable community even though she did not have social capital there. She described why she chose the rural community but also how she remained separate from the community to care for herself. *“There are challenges to working in a smaller community. Sometimes it’s just the size of the community. Especially as I am a transplant coming in, I don’t necessarily know all the community history, which sometimes that’s actually a very good thing.”*

Ms. F recognized the opportunity to leverage social and emotional capital: *“Um, small communities can be incredibly welcoming and when the chips are down, they come around. They really support each other in this community...”* Despite the opportunities, Ms. F did not describe investing in social and emotional capital. She viewed her sole role in the community as that of a professional educator. Being part of social networks was not a priority. *“They hired me first and foremost to teach. Everything else is secondary to that.”* By giving the professional context priority over personal and social contexts, Ms. F indicated vulnerabilities that decrease her potential to be professionally resilient in the rural community.

At this point in my career, I’m looking for very, very specific things so I have to go look for it myself...I am passionate about the fact that what we are doing as an education system isn’t working. It’s just not.”

Movers demonstrated professional resilience by remaining in the classroom in a new location. Vulnerabilities in the social context led to social transformation as they moved to new school settings lamenting systemic and economic vulnerabilities.

Professional Transformers

While Ms. Y recognized the vulnerabilities in her rural school context, she intentionally took adaptive actions to reach outside of the rural community to support her professional aspirations. She sought a science education leadership role.

“I’ve gone out to other kinds of places to get resources or to use things so, for example, I’m part of [a university], there’s a group that’s writing a physics curriculum and so I’m helping field test it so in that way I get a lot of the equipment.”

Lack of funding is often an issue in most schools. Yet, Ms. Y learned how to navigate economic barriers to seek the materials needed to maintain a relevant science program. She found solutions to potential barriers. Simultaneously, the professional development with the university group met personal and professional goals. *“I do all these other things because I’m interested in them, but I know that, hopefully that will give me the experience to... do something else outside of the classroom.”*

Ms. Y sought opportunities to transform roles within the science education system, *“I’m just feeling burnt out with teaching or just kinda looking to go on to the next thing because I love education.”* She was planning a professional transformation. *“I’ve actually been looking into maybe leaving the classroom and doing something else in the education field that doesn’t involve direct teaching.”* To make the transformation into science leadership, Ms. Y recognized the limited opportunities in a rural community to achieve her professional goals *“The small community is nice, and this is good for now.”* However, professional ambition is not the only force driving her desire to transform. A lack of social capital within her rural community shaped her decisions.

“You know how you were talking about helping teachers fit into this environment? I would not choose to live out here. So, this is not the environment that I want to be in so I think that is part of why I will drive out here.”

She viewed the rural community as an ideal location to teach but not to live. Ms. Y attended to her professional context and chose to not expend energy on the social context based on her career aspirations. Like Mr. K, Ms. Y did not invest in social or emotional capital, but she drew on acquired knowledge capital to transform and looked for opportunities to leave.

Discussion

When teachers can navigate both professional and social vulnerabilities in a rural community by capitalizing on places, people, and community knowledge, they can build professional resilience and remain in the rural school system. *Movers* or *leavers* only took advantage of place (and knowledge capital) and did not invest in or access emotional capital. *Stayers* drew on both professional and social capitals to adapt to vulnerabilities in the school system, whereas *movers* and *transformers* drew only on professional capital. The impact of individual teacher adaptations to vulnerabilities in their professional and social contexts has implications on the school system. At the school level, adapters who stay help maintain stability of the current system, whereas adapters who move and transform cause disrupt the system, forcing the school-level system to respond and reorganize by recruiting new teachers.

The disturbances and reorganization at the school level may or may not affect district-level and higher state-level education systems since changes in lower-level systems are slower at influencing higher levels of the whole system (Berkes & Ross, 2016). Because the actions of individual teachers affect the school system, rural school administrators must understand how *stayers*, *movers*, and *transformers* make professional decisions. Not only do rural schools need to

provide support to teachers to adapt to rural school and community contexts, the investment models for teachers how they can invest in their own students.

Only *stayers* referenced place and how they leveraged either knowledge or social capital that was place-bound. Neither *movers*, nor the *professional transformer*, explained how place supported their curricular decisions. Research indicates that individuals with a strongly developed connection to the location in which they work are more likely to remain in that position (Wang et al., 2020). Although, we initially intended to examine how rural teachers used the physical capital in their curricula, we found that teachers were primarily managing other vulnerabilities rather than seeking opportunities to use local places and people. Science teachers who can use local natural areas or local experts not only develop their own sense of place but support that development in their students (Stedman, 2016; Kudryavtsev, Stedman., & Krasny, 2012; Semken & Freeman, 2008). Mr. K expressed a desire to provide student experiences in local areas but encountered barriers with student participation extracurricular activities taking priority over academic experiences outside the classroom. Since his intentions were to only remain in [the state] for a specific amount of time, he may not have seen long term benefits in putting energy into managing this barrier. In contrast, Ms. S engaged the support of local experts to teach students about local career options. When a local expert did not respond to her request until after the event, Ms. S took the opportunity to design a future career exploration event for her students. We posit that how teachers connect to and use capital may be an indication of how they respond to perceived vulnerabilities in their school communities.

Rural science teachers who felt strongly connected to the social community and drew on social capital could manage vulnerabilities and feel professionally secure. In summary, our study

informs efforts to (1) retain rural science teachers and (2) support rural teachers by helping their students connect to local capital (physical and social places).

Implications

Every time a science teacher leaves a school, it disrupts the system, requiring remaining teachers to potentially teach out of their endorsement area. This exacerbates the problems of increasing scientific literacy in rural America. Because of the critical shortage of science teachers in rural communities (Goldring et al., 2013), it is imperative for those districts to invest in their own educational system. This study provides insight into key variables for (1) retention of rural science teachers and (2) opportunities to support rural teachers in helping their students connect to rural places. Rural science teachers would benefit from ongoing professional development and support to integrate places and local people into their curricula, making rural resources visible and explicit to their students. Science teachers might consider partnering with agricultural teachers who were seen to have natural connections and social capital in the rural community, as Ms. W and Mr. C shared with us. Such partnerships have the potential to foster both professional and social resilience.

Rural communities would also benefit from recruiting community members who are interested in becoming science teachers to seek teaching licenses and then returning to the community. Noteworthy is that, of the participants, all the *stayers* and *movers* were career changers; they became teachers to ensure employment in their rural communities. These teachers felt strongly connected to the social community and drew on social capital to feel professionally secure. Therefore, to mitigate science teacher attrition, rural school districts should recruit future teachers from rural communities, rather than assuming that non-rural teachers, who do not have local social capital, simply need to be convinced to stay in rural districts (Goldring et al., 2013).

To address the critical shortage of science teachers in rural communities, it is imperative for rural districts to invest in their own educational system.

Literature Cited

- Achinstein, B., Ogawa, R. T., Sexton, D., & Freitas, C. (2010). Retaining teachers of color: A pressing problem and a potential strategy for “hard-to-staff” schools. *Review of educational research*, 80(1), 71-107.
- Berkes, F., & Ross, H. (2016). Panarchy and community resilience: Sustainability science and policy implications. *Environmental Science & Policy*, 61, 185-193.
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77-101.
- Çiftçi, Ş. K., & Cin, F. M. (2018). What matters for rural teachers and communities? Educational challenges in rural Turkey. *Compare: A Journal of Comparative and International Education*, 48(5), 686-701.
- Coleman, J. S. (1988). Social capital in the creation of human capital. *American Journal of Sociology*, 94, S95-S120.
- Day, C., & Gu, Q. (2013). *Resilient teachers, resilient schools: Building and sustaining quality in testing times*. Abingdon, U.K.: Routledge.
- DeAngelis, K. J., & Presley, J. B. (2011). Toward a more nuanced understanding of new teacher attrition. *Education and Urban Society*, 43(5), 598-626.
- Diamond, J. B. (2012). Accountability policy, school organization, and classroom practice: Partial recoupling and educational opportunity. *Education and Urban Society*, 44(2), 151-182.
- Dupriez, V., Delvaux, B., & Lothaire, S. (2016). Teacher shortage and attrition: Why do they leave?. *British Educational Research Journal*, 42(1), 21-39.
- Folke, C. (2006). Resilience: The emergence of a perspective for social–ecological systems analyses. *Global environmental change*, 16(3), 253-267.
- Folke, C., Colding, J., & Berkes, F. (2003). Synthesis: building resilience and adaptive capacity in social-ecological systems. *Navigating social-ecological systems: Building resilience for complexity and change*, 9(1), 352-387. New York: Cambridge University Press.

- Gallopín, G. C. (2006). Linkages between vulnerability, resilience, and adaptive capacity. *Global Environmental Change*, 16(3), 293-303.
- Goldring, R., Gray, L., and Bitterman, A. (2013). Characteristics of Public and Private Elementary and Secondary School Teachers in the United States. U.S. Department of Education. Washington, DC: National Center for Education Statistics.
<http://nces.ed.gov/pubsearch>.
- Gu, Q., & Day, C. (2013). Challenges to teacher resilience: Conditions count. *British Educational Research Journal*, 39(1), 22-44.
- Holling, C. S., & Gunderson, L. H. (2002). Resilience and adaptive cycles. In: *Panarchy: Understanding Transformations in Human and Natural Systems*, 25-62. Washington, D.C.: Island Press.
- Keshavarz, N., Nutbeam, D., Rowling, L., & Khavarpour, F. (2010). Schools as social complex adaptive systems: a new way to understand the challenges of introducing the health promoting schools concept. *Social science & medicine*, 70(10), 1467-1474.
- Kudryavtsev, A., Stedman, R. C., & Krasny, M. E. (2012). Sense of place in environmental education. *Environmental education research*, 18(2), 229-250.
- Liou, Y. H., & Canrinus, E. T. (2020). A capital framework for professional learning and practice. *International Journal of Educational Research*, 100, 101527.
- Luekens, M. T., Lyter, D. M., Fox, E. E., & Chandler, K. (2004). Teacher attrition and mobility: Results from the teacher follow-up survey, 2000-01 (Education Statistics Services Institute). Washington, DC: National Center for Education Statistics.
- Nguyen, T. D. (2020). Examining the teacher labor market in different rural contexts: Variations by urbanicity and rural states. *AERA Open*, 6(4), 2332858420966336.
- Patton, K., & Parker, M. (2017). Teacher education communities of practice: More than a culture of collaboration. *Teaching and Teacher Education*, 67, 351-360.
- Printy, S. M. (2008). Leadership for teacher learning: A community of practice perspective. *Educational administration quarterly*, 44(2), 187-226.
- Ronfeldt, M., Loeb, S., & Wyckoff, J. 2013. "How Teacher Turnover Harms Student Achievement." *American Educational Research Journal* 50 (1): 4–36.
doi:10.3102/0002831212463813.

- Scheer, M. (2021). Hot topics in the classroom: Climate change education in rural schools [Unpublished master's thesis]. Colorado State University.
- Semken, S., & Freeman, C. B. (2008). Sense of place in the practice and assessment of place-based science teaching. *Science Education*, 92(6), 1042-1057.
- Showalter, D., Klein, R., Johnson, J., & Hartman, S. L. (2017). Why Rural Matters 2015-2016: Understanding the Changing Landscape. A Report of the Rural School and Community Trust. *Rural School and Community Trust*.
- Stedman, R. C. (2016). Subjectivity and social-ecological systems: a rigidity trap (and sense of place as a way out). *Sustainability Science*, 11(6), 891-901.
- Sutcher, L., Darling-Hammond, L., & Carver-Thomas, D. (2019). Understanding teacher shortages: An analysis of teacher supply and demand in the United States. *Education Policy Analysis Archives*, 27(35).
- Virapongse, A., Brooks, S., Metcalf, E. C., Zedalis, M., Gosz, J., Kliskey, A., & Alessa, L. (2016). A social-ecological systems approach for environmental management. *Journal of Environmental Management*, 178, 83-91.
- Wang, K., Li, Y., Luo, W., & Zhang, S. (2020). Selected factors contributing to teacher job satisfaction: A quantitative investigation using 2013 TALIS data. *Leadership and Policy in Schools*, 19(3), 512-532.
- Watlington, E., Shockley, R., Guglielmino, P., & Felsher, R. (2010). The high cost of leaving: An analysis of the cost of teacher turnover. *Journal of Education Finance*, 22-37.
- Wright, D. S., Balgopal, M. M., Sample McMeeking, L. B., & Weinberg, A. E. (2019). Developing resilient K-12 STEM teachers. *Advances in Developing Human Resources*, 21(1), 16-34.
- Woodbury, S., & Gess-Newsome, J. (2002). Overcoming the paradox of change without difference: A model of change in the arena of fundamental school reform. *Educational Policy*, 16(5), 763-782.
- Yin, R. K. (2009). *Case study research: Design and methods* (Vol. 5). Thousand Oaks, CA: Sage Publishing.

CHAPTER 5

EXAMINING STEM TEACHER INTENTIONS TO REMAIN IN EDUCATION DURING THE COVID-19 PANDEMIC

On March 11, 2020, the World Health Organization declared a global COVID-19 pandemic and issued recommendations on how to control further spread of coronavirus infections. In the following weeks, as the viral outbreak spread throughout the U.S., school systems reacted by initially closing school buildings and reorganizing methods to deliver instruction via remote options ranging from distributing daily or weekly printed worksheets to online platforms (e.g., Gudmundsdottir & Hathaway, 2020). For most American schools, though, instruction during the final months of the 2019-2020 school year remained remote (Malkus & Christensen, 2020; Reimers, 2022). As the 2020-2021 school year approached, the public health threat from COVID-19 continued and school systems had to once again plan instructional delivery in compliance with state and local public health policies that did not recommend teaching in person with full classroom occupancy. Without precedence in how to respond to a system-wide disturbance, schools were forced to redesign and adapt instructional approaches with the intention of meeting the needs of students in their local community to continue learning. This required teachers to adopt a variety of instructional delivery methods that, for many teachers, were unfamiliar; these ranged from fully in-person or hybrid methods designed to have half of the students in-person while the other half were remote, to fully remote or online delivery (Ehren et al., 2021). In many communities across the world, including in the U.S., teachers were asked to continually adopt new instructional delivery methods based on the levels of COVID-19 infection among the school community members throughout the 2020-2021 school year (Trust &

Whalen, 2021). These sudden system responses are cause for concern because when teachers are dissatisfied, discouraged, or do not feel prepared to meet the challenges of education, they may leave the profession, exacerbating existing teacher shortages (Rumschlag, 2017; Skaalvik & Skaalvik, 2011). However, on the flip side, these immediate responses may be perceived positively by teachers when they value responsive systemic level actions, although they may express feeling unprepared to act (Olinger Steeves et al., 2017).

One way to examine the response of the K-12 education system to the pandemic is through a systems resilience lens. Fundamentally, resilience is about change processes within acceptable boundaries outside of which the system undergoes transformation. To determine how resilient a system is, researchers identify the adaptive capacities of actors within the system and their individual and collective abilities to withstand disturbances. Resilient ecological systems, for example, are those that can return to a previous state following a disturbance (Berkes & Folke, 1998; Gallopin, 2006); and as such, resilience helps researchers measure the magnitude of disruption that a system can tolerate before the system changes its structure (Nelson, 2011). Theoretically, systems that are managed for resilience should have the capability of adapting for self-reorganization. Yet, in dynamic environments and contexts, it is difficult to predict when and to what magnitude a system will encounter a disturbance. Additionally, the boundaries or thresholds for transformation will move over time, requiring system managers to continually monitor the response to perturbations of the system. As the COVID-19 pandemic illustrated, American school systems may have been prepared for some level of disruption, yet the fact that the pandemic has not ended 18 months later has clearly placed a strain on school systems and the actors within them (Reimers, 2022).

Although there are many differences between bio-physical systems and socio-economic systems, the ecological study of system resilience can inform our understanding of the K-12 educational system. The K-12 education system is a set of nested systems (Keshavarz et al., 2011). Regardless of the focal point for beginning to examine a system, each system level affects actors in levels above or below that point. For example, a school is part of a system made up of diverse actors (students, parents, teachers, and administrators) nested in larger district and state educational systems in which administrators make decisions that are often (but not always) in alignment with local, state, or national policies. Teachers are simultaneously *influenced by* the system through system actions to maintain resilience and also *actors in* the system with the potential to influence how the system adapts to disturbances (Wright et al., 2019). When a disturbance occurs in a school system, such as the adoption of new academic standards, both the system and the individual respond. As systems adopt new resources to address the content of the standards, teachers are adapting to the instructional delivery of the standards while using the provided resources. While both the system and the individual respond to the disturbance, they do so in different — neither inevitably contradictory, nor complementary — ways.

An ecological systems model focuses on the system as a whole and the adaptive capacities of the *groups* within it (Berkes et al., 1998). However, because social economic systems, such as schools, are made up of *individuals* that have adaptive capacities or the ability to act, it is important to examine the individuals, their perceptions of the system, and their perceived capacity to respond to disturbances that likely affect their behaviors, which, in turn, affect the system's tolerance for resilience. Within school systems, it is particularly critical to understand how teachers respond to sudden professional upheavals because of persistent attrition and shortages of science, technology, engineering, and mathematics (STEM) teachers across the

country. By documenting how teacher perceptions affect their professional plans (i.e., to remain in or to leave) STEM teaching, teacher educators can be better prepared to support teachers and school systems more generally. It was within this context that we questioned secondary STEM teachers about their experiences managing new expectations regarding instructional delivery and the impact of these changes on their intentions to remain in the teaching profession. Here, we describe teachers' perceptions of how school systems responded to the pandemic, their own capacities to respond to these changes, and their decisions to remain or leave the profession.

Conceptual Framework

A challenge when using literature and frameworks from one field (e.g., natural science) and applying them to another (e.g., social science) is that it can be confusing when terms are operationalized differently in the two fields (Keshavarz et al., 2010). Therefore, it is vital to explicitly define concepts so distinct audiences develop a shared understanding of the terms. In educational research, the concept of resilience is often applied to both the system and the individuals within the system (Day & Gu, 2013). While a resilience systems framework can be used to describe the *education landscape*, social cognitive theory (Bandura, 1977) provides an appropriate framework to examine the *individuals* within the system and their adaptive capacities to manage system-level disturbances. The behaviors of individuals are influenced by both their personal contexts (knowledge and attitudes they possess to achieve their goals) and the environment in which they act and make decisions. Teachers draw on their personal and professional contexts when taking action in the school system to reach their personal and professional goals. For example, some individuals plan for a long career in the classroom while others strive for leadership or administrative roles in the education system (Gubler et al., 2017). They each exhibit adaptive capacity by drawing on resources and capitals from both their

personal and environmental contexts throughout their career (Lockwood et al., 2015). Capital refers to skills, knowledge, experience, and agency possessed by a teacher and is viewed in terms of their value to the success of the system. (Nolan & Molla, 2017). An individual with adaptive capacity, therefore, anticipates disturbances in the school education landscape, identifies resources and capitals, and plans to use these resources and capitals to manage the disturbances and achieve individual goals. In other words, they can be considered professionally agentic (Bandura, 1989).

Scholars of teacher professional agency categorize teachers as stayers (those who remain in the same role in the same school system), movers (individuals who move roles or to alternative education systems), and leavers (individuals who exit the education system) (Bobbitt et al., 1994; Luekens et al., 2004). The range of teachers' personal and professional adaptive capacities contributes to their decisions to stay or leave (Chiong et al., 2017). Moreover, the level of professional experience undoubtedly shapes teachers' perceptions of their work environment, their personal attributes, and the ability to enact their professional goals (Toom et al., 2015). Professional teachers (those who have persisted for more than five years) are an integral component of the education system. They individually and collectively manage both personal and professional challenges during system disturbances. Although past research on teacher professional adaptive capacities often focused on describing how teachers navigate the *chronic* disruptions to their professional lives, the COVID-19 pandemic provides an opportunity to study how teachers perceive and navigate *sudden* and *unexpected* disruptions.

In this study, we explored the adaptive capacities of STEM teachers and describe how they responded to a large-scale disturbance in the education system, which was in the process of reorganization following the COVID-19 outbreak. We asked the following question:

How did STEM teachers at different professional stages both perceive (the system and their success) and **respond** to their professional landscapes (by remaining or leaving) during the unexpected crisis and major disturbances caused by COVID-19?

Methods

A longitudinal, mixed method design was used to investigate the research questions (Creswell, 2021). We surveyed the same group of teachers three times over a ten-month period, and interviewed a subset of these, allowing us to track changes over time and explore variables that may explain why the changes occurred. Through survey responses, we assessed the magnitude and significance of changes over time, and through focus group interviews, we characterized participants' perceptions of their professional context.

Participants

The National Science Foundation (NSF) funds Noyce programs in teacher licensure programs at colleges and universities across the U. S. Noyce programs recruit and support high quality pre-service and in-service STEM teachers who commit to teaching in school districts that meet designated “high needs” criteria. Noyce Scholars receive scholarships for their university studies and become part of a large network across the U.S. The program leaders at 14 NSF Noyce programs from across the Great Plains and Western States were recruited through the authors' professional networks. The principal investigators of each of these programs agreed to distribute study recruitment emails to their current and former Noyce Scholars.

A total of 153 preservice and professional STEM teachers responded to the Round 1 survey. Data from these initial questions indicated that 81% ($n = 123$) of the participants identified as STEM classroom teachers, while 15% ($n = 23$) described themselves as preservice STEM teachers and 4% ($n = 6$) as those no longer in the education system. The majority of

participants taught in middle or high school science classrooms ($n = 113$, 73%), whereas 15% ($n = 23$) were mathematics teachers, 10% ($n = 15$) taught in multiple STEM content areas, and >1% ($n = 2$) in engineering or technology classrooms. Of the 79 participants who expressed interest in semi-structured focus group interviews, 42 registered for and attended one of the 13 focus group sessions conducted in Winter 2021. All participants were offered a monetary incentive.

Data Collection

The longitudinal survey design included the dissemination of three online surveys. The first survey (Survey 1) was distributed in Spring 2020, the second (Survey 2) in Early Fall 2020, and the final survey (Survey 3) in Late Fall 2020. Following the three surveys, participants were invited to semi-structured focus groups in Winter 2021 to elaborate on their experiences in their school context and how it was impacting their professional resilience. In total, thirteen focus groups were conducted, each ranged in size from one to five participants. They were facilitated by a science teacher who was not a Noyce Scholar.

Study Instruments

The surveys were distributed through Qualtrics software over seven months. An initial analysis of responses in Survey 1 informed questions for Survey 2 and, in an iterative process, an analysis of Surveys 1 and 2 informed questions for Survey 3. Survey 1 collected teacher demographics used open-ended questions to inquire about perceptions of how the school district, school, and the individual responded to the beginning of the pandemic in Spring 2020. Survey 2, delivered in Early Fall 2020, used the same open-ended questions as Survey 1 to inquire about teachers' perceptions of the school district and school landscape as these systems had time to plan a pandemic response for the new school year. Additional open-ended questions asked about

the professional opportunities and challenges teachers were facing during the pandemic. Five-point Likert scale questions gauged the strength of variables related to teachers' commitment to STEM education. Survey 3 collected teacher's intentions to remain in STEM education and variables that influenced their intentions using a mix of open-ended, five-point Likert scale, and ranked choice items. The final survey was followed up with semi-structured interviews in focus groups of up to five teachers lasting sixty minutes each. The interview protocol included open-ended questions probing teachers' professional intentions and the role of the pandemic on influencing those intentions. This study drew on the data from the surveys and focus group interviews supporting answers to the research questions that described the system landscape and how individuals navigated that landscape.

Data Analysis

Perceptions of the System and their Own Success. To explore how STEM teachers from across a range of professional experience **perceive** their professional landscapes during the unexpected crisis and major disturbances caused by COVID-19, we used responses to the questions, "What actions is your school district taking in response to the COVID-19 pandemic?" and "What actions is your school taking in response to the COVID-19 pandemic?" in Surveys 1 and 2 to conduct a thematic analysis (Braun & Clarke, 2006) using Dedoose (Version 9.0, 2021). Data elements were coded to describe the system reorganizing actions taken by school districts and schools. A second deductive analysis using the same text categorized participants' perceptions of available resources and capitals as positive, negative, neutral, or mixed. Teachers coded as having positive beliefs described multiple resources and capitals within the education system, while those coded as having negative beliefs described having a lack of available

resources and capitals. These perceptions of resources and capitals accessible to teachers were connected to how teachers perceived their professional landscape.

Response to the System. To understand how STEM teachers **respond to** their professional landscapes during the unexpected disturbances caused by COVID-19, we first used demographic data from Survey 1 to categorize participants based on their professional experience as teachers as of Spring 2020. Four categories were created: (1) individuals working toward teacher licensure and having no years of experience independently in a classroom were grouped as *preservice* teachers, (2) those with one to three years of experience were categorized as *novice* teachers (Barrett et al., 2002), (3) those with four to five years of experience were categorized as *early career* teachers, and (4) those with six or more years of experience were categorized as *master* teachers (Rivkin, Hanushek, & Kain, 2005). To explore perceptions of professional success, we analyzed items from using responses in Survey 3. Specifically, ANOVA tests were run using SPSS 26 to analyze differences across these four categories (e.g., preservice, novice, early career, and master) in perceptions about professional success prior to and during the pandemic, and their reported intentions to remain in the STEM classroom.

To further explore intent to stay or leave the profession, we analyzed focus group transcripts to identify what variables may influence professional decisions using both deductive and inductive methods. Questions about intentions to stay or leave teaching were asked in both Survey 3 and the focus group, which were used to triangulate survey results. Focus group transcripts were deductively coded within Dedoose 9.0. The deductive codes included: (a) intent to remain in their current school district as a teacher, (b) intent to remain in their current school district but in another role, or (c) intent to leave the K-12 education system. The follow-up focus group responses to questions about staying or leaving teaching were inductively coded using

thematic analysis. This process allowed us to identify themes of teachers' perceived capacities or limitations to remain or leave the STEM classroom (Fereday & Muir-Cochrane, 2006).

Trustworthiness

To promote trustworthiness, reduce bias, and make the analysis process transparent, two authors conducted the qualitative analyses. The inter-rater reliability was initially 80% , and all discrepant codes were discussed and clarified until full agreement was met. The findings were shared with all authors through a process of peer debriefing. Although the debriefing did not result in revising codes, it challenged us to ensure that our claims were supported with evidence.

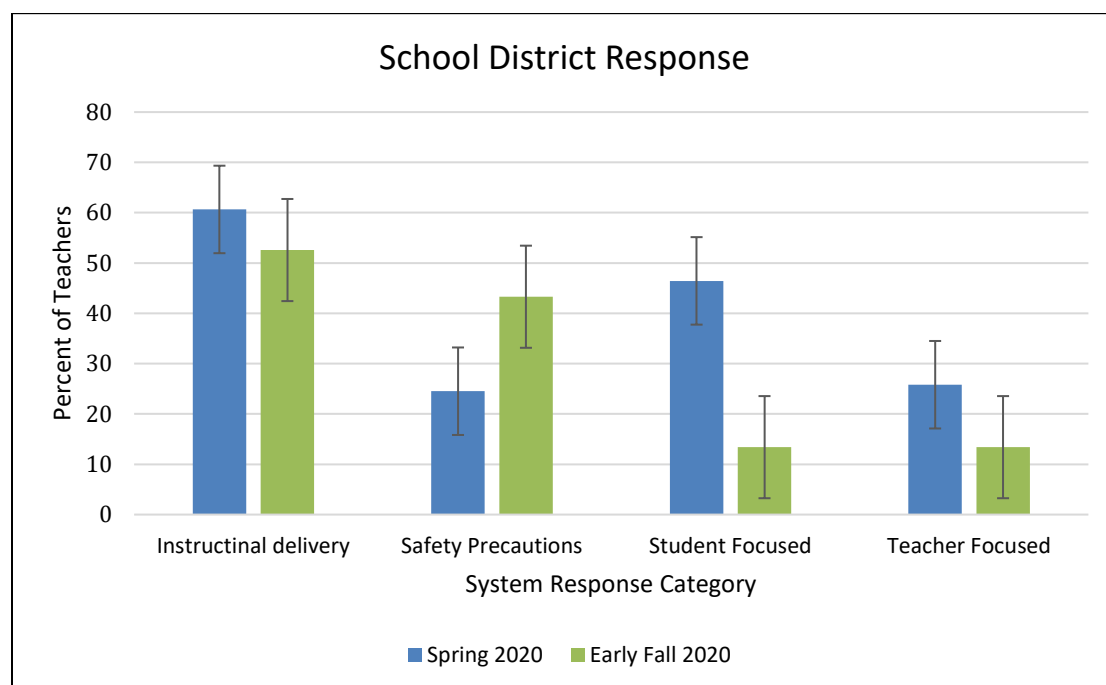
Findings

Social cognitive theory helps explain how people's behavior is shaped by their perceptions of themselves and their environment. Likewise, the participants in our study expressed professional behaviors (staying or leaving teaching) as a consequence of their feelings of success and the system response. Teachers describe their views of the school district and school *environment* during the COVID-19 pandemic, their *beliefs* about their role in the changing environment, and how these both influence their professional *intentions* in looking toward the next school year.

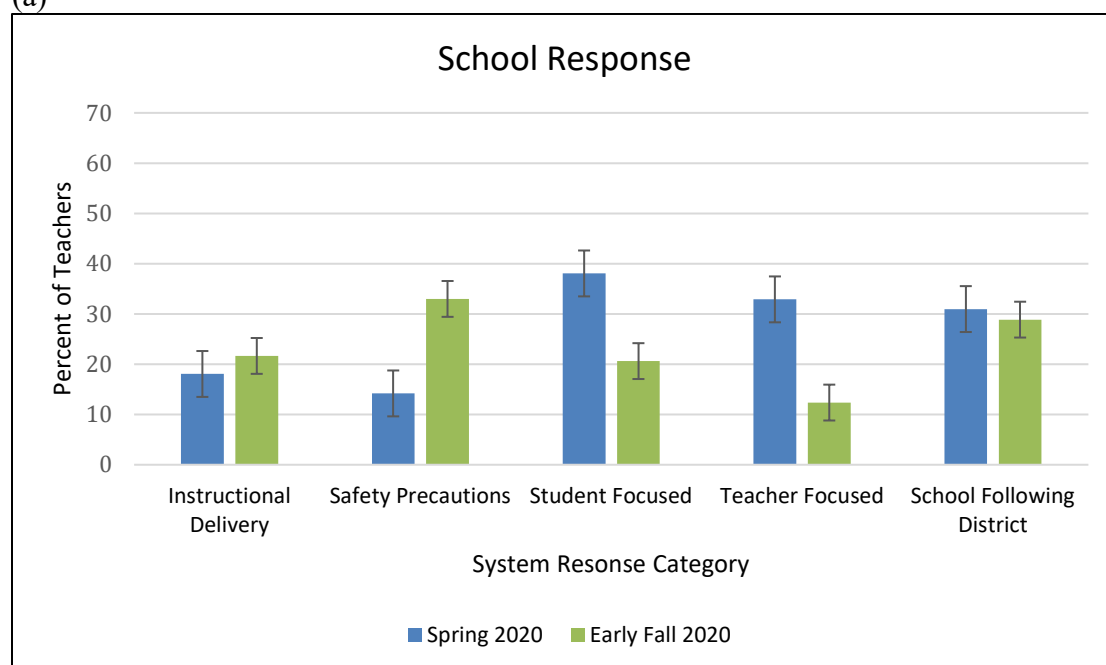
Environment

Perceptions of the System Response. When systems experience a disturbance, actors within it are pushed to respond and potentially reorganize to maintain each system's designated function. The disruption to education at all levels of the system from the COVID-19 pandemic forced an unplanned reorganization. Participants were asked open-ended questions in Surveys 1 and 2 about the actions their school district and school took in response to the public health crisis. Figure 5.1 shows the number of survey respondents describing the district and school level

system actions. Teachers perceived that school districts took the lead in dictating how schools should react to maintain continuity of student learning amidst a public health crisis.



(a)



(b)

Figure 5.1. Teacher Perceptions of Education System Responses to COVID-19 Pandemic

In spring 2020, teachers most frequently perceived that school districts responded to the pandemic by focusing efforts on the **instructional delivery** ($n = 94$, 60.7%) and **safety procedures** ($n = 38$, 24.5%; Figure 5.1a). As schools started closing, teachers described districts as quickly shifting to remote instructional delivery ($n = 78$, 50.3%) because governmental public health emergency mandates prohibited or warned against public gatherings. The threat of contracting or spreading the disease in educational spaces decreased by having students and staff physically avoid school buildings. **Student-focused responses** ($n = 72$, 47%) taken by districts included reactions to concerns for student wellness and learning progress. Some teachers described multiple student-centered responses like access to technology, such as digital devices and internet access, for students to access learning materials or participate in lessons ($n = 31$, 20%). Teachers also described changes to district grading policies ($n = 25$, 17%). In addition, teachers noted school districts' concern with students' food security ($n = 23$, 15%) particularly those who depend on school nutrition programs for daily meals. In addition to district responses related to instructional delivery, safety, and student-centered concerns, twenty-five percent ($n = 40$) of the teachers responded with comments categorized as **teacher-focused**, referencing staff communication from the school district about how the system was reorganizing to continue instruction most frequently ($n = 14$, 9%).

As the 2020-21 school year approached and the COVID-19 pandemic continued to affect communities, school systems had to again reorganize for instruction. School districts were able to use the summer months to plan for different ways to provide instruction based on local rates of infection while complying with public health policies. In early fall, 53% of teacher survey responses addressed the system-level reorganization around **instructional delivery**. While 44% of the teachers indicated that instruction would be remote, 18% indicated that they were teaching

in a hybrid format with a reduced number of students physically present. Teachers ($n = 42$, 43%) were expected to adopt and enforce a variety of new **safety precautions** if they were expected to teach in-person and online simultaneously; precautions such as social distancing, increased hand washing, mask wearing, and sanitizing desks frequently. According to participants, **student-focused** actions ($n = 13$, 9%) taken by school districts decreased in Early Fall 2020 (Survey 2) although they continued to express a concern about students' access to technology ($n = 6$, 6%). Fewer teachers reported **teacher-focused** ($n = 13$, 13%) actions, and these shifted from staff communication to professional development in frequency.

Participants' perceptions of the system response at the school level differed from their perceptions of the district level response as schools were operationalizing school district responses by **following the district lead** (Spring $n = 48$, 31%; Early Fall $n = 28$, 29%; Figure 5.1b). In spring, as the pandemic began, teachers indicated that the school responded by attending to **student-focused** concerns ($n = 59$, 38%) by checking-in with students ($n = 29$, 19%) and distributing curricular materials ($n = 18$, 12%). Schools were described as being more attentive to **teacher-focused** concerns ($n = 51$, 33%) , such as staff communication ($n = 21$, 14%). Fewer teachers indicated that **instructional delivery** ($n = 28$, 18%) and **safety precautions** ($n = 22$, 14%) were concerns of the schools.

In early fall, teachers' perceptions of school actions more closely aligned with their perceptions of district actions as they described **instructional delivery** ($n = 21$, 22%) and **safety precautions** ($n = 32$, 33%) most often. **Student-focused** ($n = 20$, 21%) and **teacher-focused** ($n = 12$, 12%) responses decreased.

In summary, teachers perceived in spring that they were a lower priority for the district system level but a higher priority at the school system level, whereas by early fall, they perceived

that they were a low priority at both system levels. They were asked to keep the system functioning and meet the needs of students without being asked what they needed to perform this critical function.

Beliefs

Beliefs about the System Response, Open responses in Surveys 1 and 2 were analyzed to examine the teacher's beliefs about the education system's response to the pandemic in spring 2020 and early fall 2020. Teachers were asked to identify resources or lack of resources in the district and school system that they perceived supported or hindered their work efforts (Table 5.1). Comments coded as **positive responses (4.59%)** described resources that provided opportunities and support for teaching and learning. Participant 125 reported that their school had *“great communication with parents, staff, and students.”* While Participant 072 wrote that the school district provided *“three weeks to prepare for online learning...the district offered professional development on how teachers can move their classrooms over to the online environment...[district] made sure to get every student a Chromebook and hot spot if they needed one.”* Teachers believed that the system provided professionally meaningful resources and capital in the form of time, professional development, and technology resources. Notably, almost half of the teachers believed that the system response was **negative (48.51%)** with adverse effects on their teaching. For example, participants shared the following comments: *“The volume of emails we get is absurd. Complaints from parents and demands to give special accommodations left and right are out of control,”* (Participant 141). This response illustrates the belief that the system lacked providing support in the form of time to and processes for managing requests from parents. This participant continued explaining that the *“Workload is not realistic...[I] have to work all weekend to get ready for the next week - panic attack and ready to*

quit" (Participant 141). Some respondents' comments were coded as **neutral (44.55%)** because they did not insinuate that system-level actions had either a positive or negative impact on their teaching. For example, Participant 016 said they "*plan to just go with the flow the best I can...I do not plan to be a 'super teacher' this year, but to just survive.*" Finally, there were responses that included both positive and negative beliefs that were then categorized the individual as having a **mixed sentiment (1.98%)**. In summary, teachers were more likely to believe that the system response was either negative or neutral. Furthermore, when teachers were grouped based on years of professional experience, the frequency of individuals categorized as having positive beliefs was significantly less than the percentage having negative and neutral beliefs for all categories of years of teaching experience.

Table 5.1. Teacher Beliefs about the School District and School Response to COVID-19 Teacher survey responses reflected positive, negative, neutral, or mixed beliefs about the education system response to the pandemic. Beliefs did not significantly differ based on years of experience.

Professional Stage	Teachers n	Positive Beliefs		Negative Beliefs		Neutral Beliefs		Mixed Beliefs	
		n	%	n	%	n	%	n	%
Preservice	16	0	0	7	43.75	8	50.00	1	0.06
Novice	48	4	0.08	25	52.08	19	39.58	0	0
Early Career	22	1	4.55	10	45.45	11	50.00	0	0
Master	15	0	0	7	46.67	7	46.67	1	6.67
TOTAL	101	5	4.95	49	48.51	45	44.55	2	1.98

Beliefs about Professional Success. In Survey 3, teachers described success in the classroom as "*a high level of engagement, enthusiasm, and appropriate rigor*" (Participant 081) of the material and the "*ability to connect with my students and offer them opportunities to have discussions and challenge their thinking with different perspectives and interconnections between varying content*" (Participant 149) with students to see that they "*are provided for,*

protected, and moving forward” (Participant 008). After defining success, teachers were asked to rate their feelings on a five-point scale about their success as an educator prior to the pandemic and in late fall 2020, when the survey was administered. Teachers were categorized based on years of experience to examine the data for differences between groups. All four groups of teachers (e.g., preservice, novice, early career, and master) perceived high levels of success in the classroom prior to the pandemic with early career teachers reporting the highest level of success ($n = 13$, $M = 4.46$; Fig. 5.2). Prior to the pandemic, the perceived success of master teachers ($n = 33$, $M = 4.27$) showed a statistically significant difference ($p < 0.05$) from preservice ($n = 21$, $M = 3.48$) and novice ($n = 34$, $M = 3.82$) teachers. There were no differences between groups when teachers reported perceived success during the pandemic.

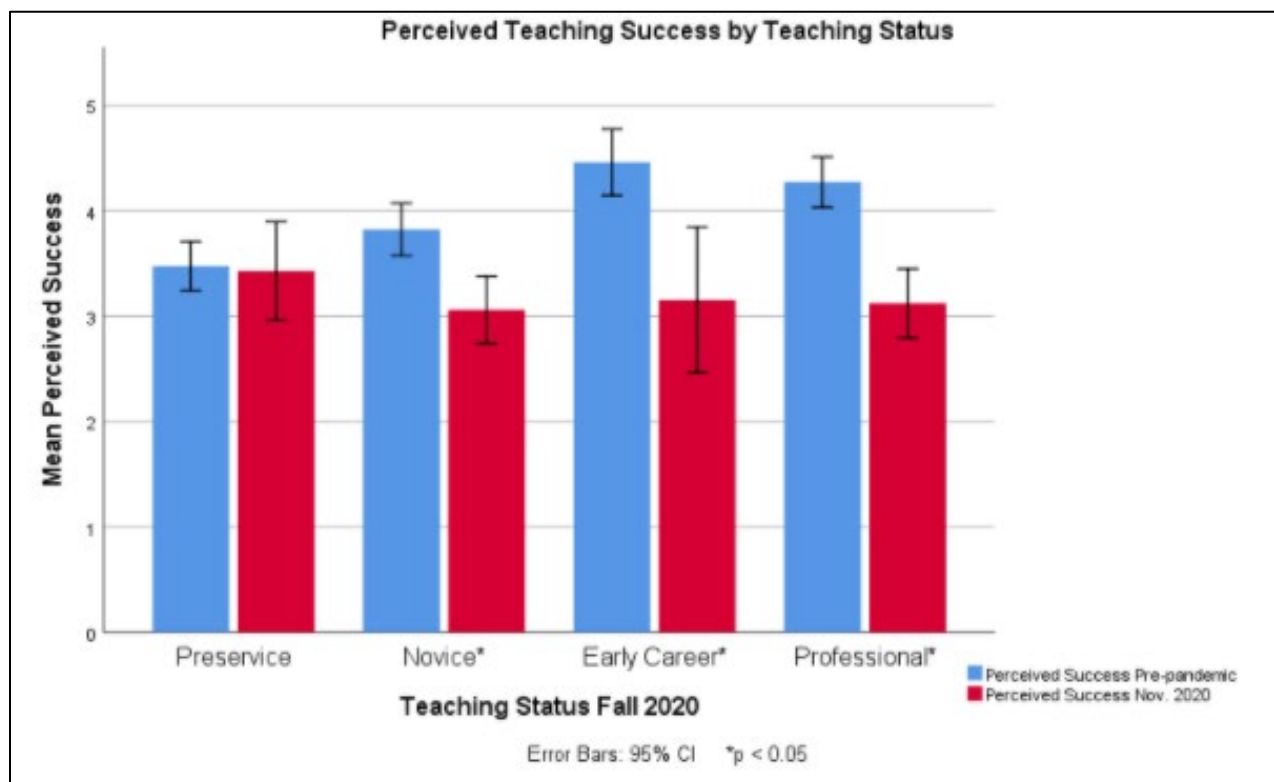


Figure 5.2. Teacher Perceptions of Success by Years of Experience

Behavior: Professional actions

Intentions to Remain in the Classroom. In Survey 3, we asked participants specifically to rate their likelihood to remain in the classroom for: (a) 1 year (i.e., this school year), (b) 2 - 4 years, (c) 5 - 10 years, and (d) 10+ years. (Fig. 5.3). Teachers indicated their intentions using a five-point Likert scale. All four groups of teachers indicated that they were highly likely to remain in the classroom for the remainder of the school year (preservice $n = 20$, $M = 4.60$; novice $n = 40$, $M = 4.62$; early career $n = 11$, $M = 4.82$; and master $n = 27$, $M = 4.67$) with no statistical differences between groups. As teachers indicated their intentions to remain in the classroom in future years, differences emerged within groups. While preservice teachers were highly likely to see themselves in the classroom for ten or more years ($M = 4.00$), there was a statistical difference ($p < 0.05$) between these future intentions and their intentions to remain for the rest of the school year ($M = 4.57$). For all other teacher groups, novice, early career, and master, there was a within group statistical difference between remaining for the current school year and all other options, 2 - 4 years, 5 - 10 years, and 10+ years, where each year the likelihood of remaining in the classroom decreased. When comparing means between groups, statistical differences emerged ($p < 0.05$) between the responses of preservice and novice teachers for the questions indicating their intentions to remain in the classroom for 5 - 10 years (preservice $M = 4.38$, novice $M = 3.25$, early career $M = 3.42$, and master $M = 3.52$) and again for 10+ years (preservice $M = 3.95$, novice $M = 2.85$, early career $M = 3.38$, and master $M = 3.15$) with preservice teachers having a higher mean. In summary, all participants indicated a short-term commitment to the STEM classroom with the strength of the commitment decreasing projecting five or more years in the future.

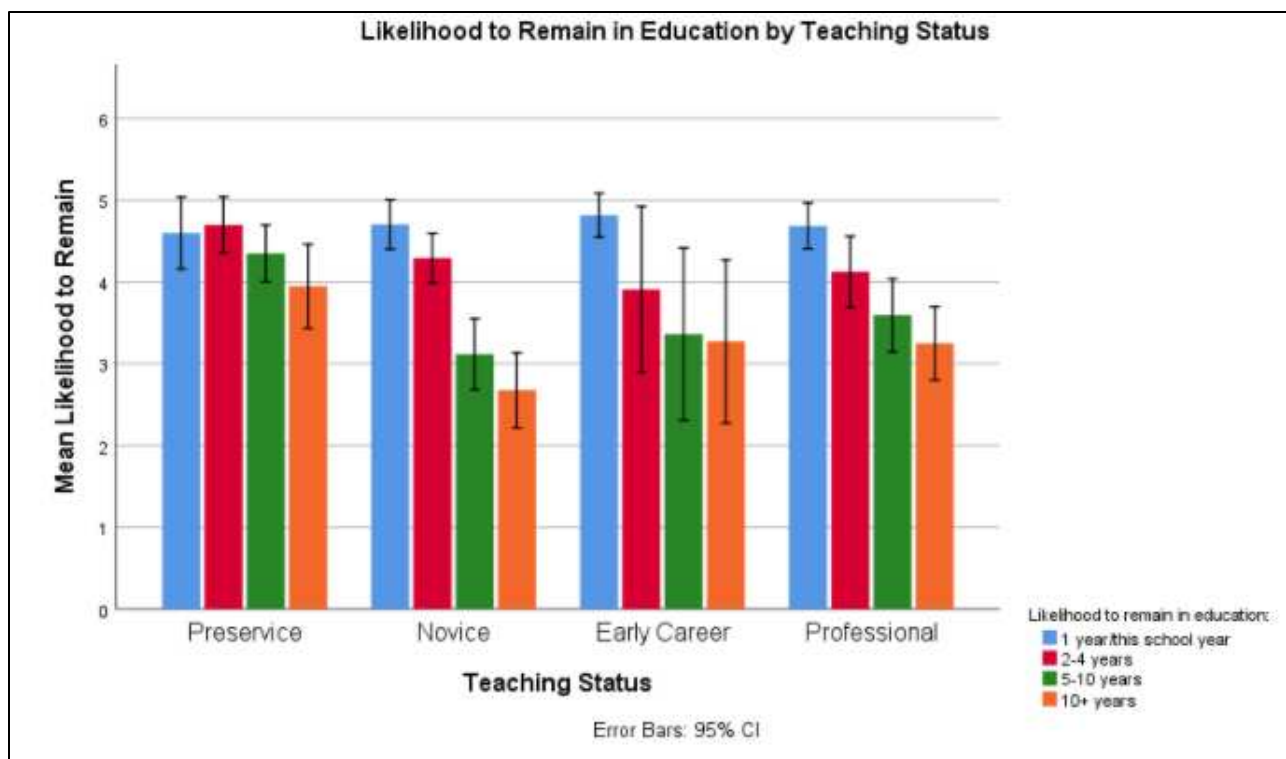


Figure 5.3. Teacher Intentions to Remain in the Profession

Variables Influencing Participants' Intentions. In Survey 3, teachers were invited to participate in focus groups during Winter 2021 to better understand their experiences as teachers following 11 months of multiple pandemic responses by schools and districts. Participants were explicitly asked to share their professional intentions related to remaining in the STEM classroom and their reasons for staying, moving, or leaving. While most focus group participants responded that they intended to stay in the same school ($n = 28$) as a classroom teacher, the teachers who were moving locations ($n = 6$) all indicated they would be seeking equivalent classroom teaching positions, although three teachers described possibly leaving the education system for other opportunities. In summary, teachers expressed a range of behaviors: staying, moving, and leaving.

Thematic analysis revealed patterns that align with internal (personal) and external (system) contexts and that revealed teachers' perceived capacity to recognize opportunities or

limitations when trying to meet professional expectations during the pandemic (Fig. 5.4). Teachers coded as believing they had capacity because they could access internal (personal) resources described self-efficacy. *“I just love teaching”* (Participant 072) and *“I can see teaching as an investment in my community and children”* (Participant 152). Teachers coded as believing that they had capacity due to access to external (system) resources described professional development and supportive administrators. *“There’s a supportive administration that has made me feel valued during this time”* (Participant 147). Limitations were also described by teachers during the focus group interviews. Participant 079 explained their internal *“outlook has changed on teaching after the pandemic...my commitment is still there, but I don’t know if I’ll necessarily be a lifetime teacher”* and Participant 053 described *“I think I’ve never worked harder in my life and been less effective”*. The system also presented teachers with limitations. *“I don’t want to be stuck in that feeling of isolation...like talking to a blank screen”* (Participant 008). Participant 102 described the limitations they see in the system as *“from all of the schools I’ve been around recently has been over promising and under delivering”* in regard to communicating school plans to have remote or hybrid delivery of instruction.

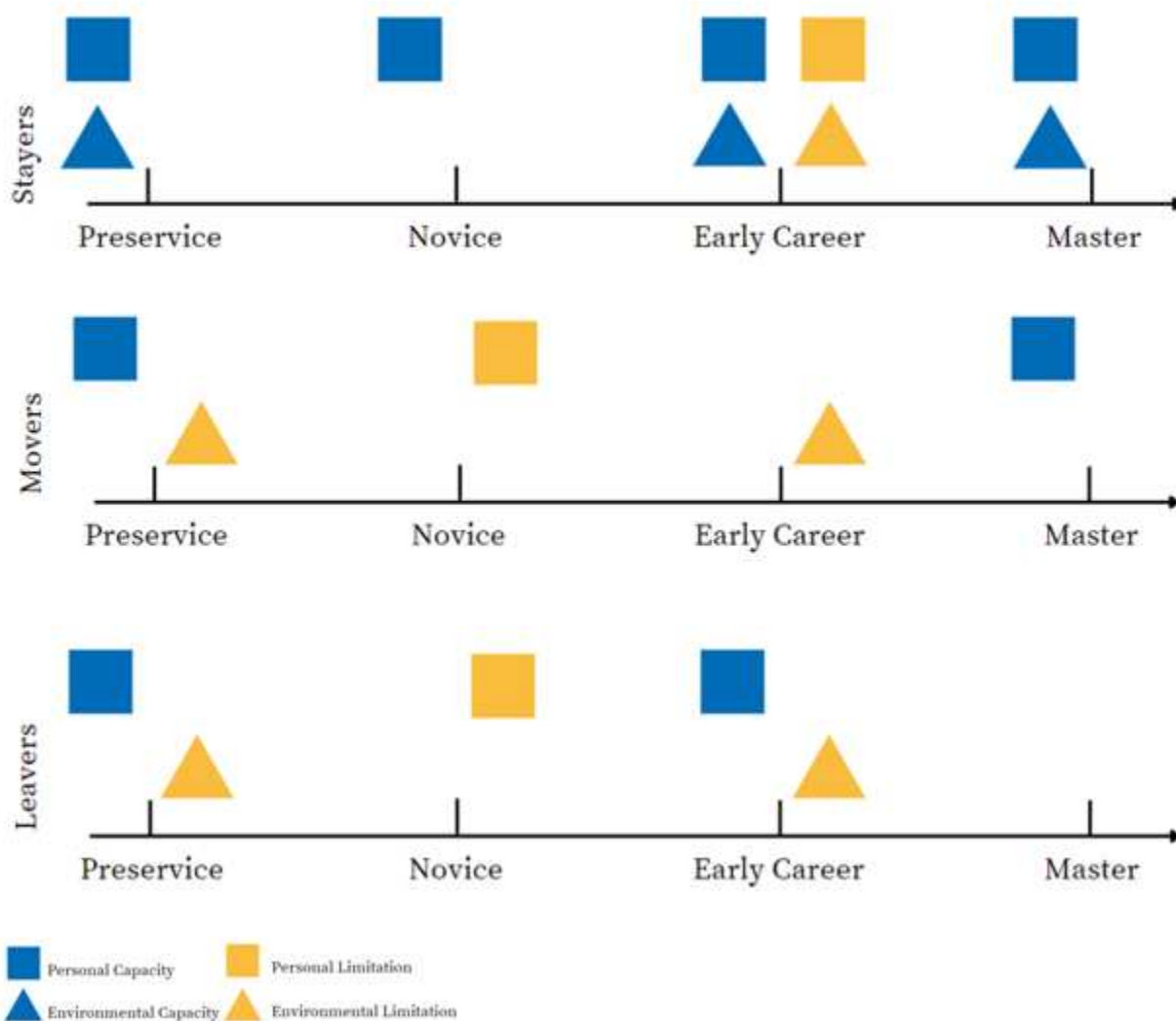


Figure 5.4. Variables Influencing Teachers' Decisions to Stay, Move, or Leave

Teachers' intentions to stay (remain in the same classroom), move (move to another but remain in the classroom or move to another position within education), or leave (exit the education system) are influenced by internal (personal) and external (environmental) variables. Teachers may perceive these variables as providing capacities or limitations to achieving their intentions.

Preservice teachers perceived capacities, both internal and external, as variables driving them to the STEM classroom. Novice teachers reported drawing on internal capacities. Early career teachers perceived both internal and external capacities and limitations as supporting their intentions to stay. Master teachers' perceptions were similar to preservice teachers' perceptions.

of being affected by both internal and external resources that shaped their perceptions of their own professional capacity to withstand professional disruptions.

Teachers who were coded as movers, regardless of whether they were novice, early career, professional, or master teachers, identified limitations as the impetus for their decision to move from one school to another. Novice and master teachers perceived their limits to be internal (i.e., personal), whereas preservice and early career teachers perceived their limitations to come from external sources (i.e., system responses). Preservice movers were the only group coded as also believing that they had internal capacity.

Each of the leavers described a different variable influencing their decision. The preservice teacher perceived an internal limitation preventing their entry into the STEM classroom. The novice teacher perceived external capacities that would allow them to leave the education system while the early career teacher perceived external limitations in the system as well as internal capacities influencing their intentions. No master teachers in the focus group interviews indicated an intention to leave the education system.

Discussion

National academic standards were designed to develop students' critical thinking skills across disciplines, preparing them to become engaged citizens. Teachers are critical in supporting students' learning. Historically, in the majority of schools across the U.S., teaching occurs face-to-face in school buildings. Most teachers get to know each of their students, as well as their socio-emotional and learning needs. They create classroom environments that foster both academic and social growth. The declaration of a global pandemic and the practices that communities enacted to contain the spread of the coronavirus severely disrupted the routines of schools. Although education systems have adaptive capacities to manage chronic disturbances,

they were unprepared and inadequately resourced to manage the magnitude of the impact of a pandemic (Huck & Zhang, 2021). School districts and schools had to quickly re-organize policies and procedures to continue to function as a system while meeting the academic and physical needs of students and the professional needs of teachers. The ability to attend to the normal operations of the system and thereby the ability to operate normal education programs was diminished (Reimers, 2022).

Actors working together, along with physical contexts, comprise systems. Therefore, when education systems were forced to respond to the pandemic, the need to characterize how teachers responded became critical. In this study, we studied highly achieving and supported STEM teachers through surveys and focus groups to synthesize their beliefs about their own capacities, their beliefs about the school systems in which they operated, and their professional intentions to remain in teaching or not. In response to the unexpected disruption of the pandemic teachers perceived 1) the education system responded by prioritizing the reorganization of instructional delivery, 2) the shift in instructional delivery decreased teachers' perceptions of their own success, and 3) in spite of the major disturbance to their traditional methods for interacting with students, teachers intended to remain in the classroom for the short term.

Environmental - Navigating a changing landscape

To understand teachers' professional intentions to remain or leave the classroom, it is important to describe teachers' perspectives of their professional environment. During the COVID-19 pandemic, teachers described how school districts quickly reorganized for remote forms of learning which resulted in teachers having limited contact with students. Teachers perceived this drastic change from how school systems typically operated to new expectations of instructional delivery in negative terms (Burkman, 2012). They believed that the system response

adversely affected their ability to be successful teachers. Teachers believed that administrators did not value their roles and instead prioritized the continuation of instructional delivery from the onset of the pandemic as the primary strategies to maintain system resilience. Similarly, Zieher and colleagues found that when teachers felt supported by administrators, they believed they were better able to teach socioemotional learning, but those who did not feel supported, were more likely to describe dissatisfaction with their own teaching abilities and feelings of professional burnout, a precursor to leaving the profession (Rumschlag, 2017).

Beliefs - Agency

As teachers viewed the changing professional landscape, most reported a negative or neutral perception of the new system. They found their school districts or schools to be more concerned with assuaging parents and community members, rather than tending to their own personal and/or professional needs. They believed administrators were most concerned with maintaining the appearance of a resilient system and that, as actors in the system, they were expected to comply. Mansfield and colleagues (2014), in their study on the resilience of early career teachers, reported that teachers are more likely to report system-level and contextual barriers than personal attributes. They cautioned schools and teachers educators that this could result in early burnout of teachers (Gavish & Friedman, 2010; Rumschlag, 2017). Although the majority of the teachers in our study did not describe burnout, most did convey feelings of dissatisfaction with system leaders.

Prior to the pandemic, teachers perceived a high level of individual success in their professional roles. Teachers who had been in the field relatively longer (i.e., early career and master teachers) reported feeling they had higher degrees of success than what was reported by teachers with less experience (i.e., novice and pre-service teachers) in the classroom. Teachers

who referenced their own personal capacity to withstand changes and uncertainty are often described as having agency (Balgopal, 2020; Priestley et al., 2015). Thus, more experienced teachers may feel more successful when they are able to draw on past experiences both personal and from the classroom to inform their current beliefs and behaviors while simultaneously considering how the past and present will influence future instructional actions (Wright et al., 2021). When teachers lack past experiences, they may perceive a loss of professional agency. With the sudden shift in methods of instructional delivery during the pandemic, teachers at all experience levels reported a lack of experience with resources and methods for delivering remote instruction (Hartshorne et al., 2020; Hodges et al., 2020).

Following nine months of teaching in a pandemic and navigating system disruption and reorganization, teachers perceived their success to be greatly diminished. The system response to dictate new policies and procedures for how teachers would deliver instruction to students eliminated the “experience advantage” for teachers with more years in the classroom. Many teachers described feeling like they were repeating their first year of teaching. They described having to learn and develop new strategies for engaging and assessing students. In other words, their sense of agency decreased without past experiences to draw on and the uncertainty of how they would be interacting with students as the system disruptions continued (Edwards, 2015; Gudmundsdottir & Hathaway, 2020).

Behavior - Intentions

Teachers are often described as stayers, movers, or leavers from their current classroom assignment based on their actions for the next school year (Bobbitt, 1994). Research shows that across the U.S., typically 8% of teachers move to new schools and 8% are leavers in a typical year (Carver-Thomas & Darling-Hammond, 2017). Teachers’ intended behaviors to remain in or

leave the classroom are influenced by their perceptions of their professional and personal context (Woodbury & Gess-Newsome, 2002). During the pandemic, the participants in our study, STEM teachers of all levels of professional experience, expressed intentions to remain in the classroom short term (through the end of the school year). In spite of the negative perceptions of the changing education landscape and feeling a lack of success, in the midst of Winter 2021 the participants were committed to their profession even with a lack of knowledge or training about new resources (Gudmendsdottir and Hathaway, 2020). Teachers are often willing and able to cope with professional disturbance. When asked about intentions to remain in future years, though, responses of participants varied. Preservice teachers who were on the cusp of entering the education profession, indicated intentions to remain in the classroom for a long career in STEM teaching. This is consistent with the literature showing that preservice teachers' brief encounters with the school environment prior to being hired for their first classroom position coupled with the immediate support from mentor and cooperating teachers during their student teaching experiences result in naivete about the challenges faced by fully licensed teachers (McLennan et al., 2017; Stites et al., 2019).

All teachers indicated intentions to remain in the classroom for the short term but were more hesitant when projecting five and ten years into the future. Novice teachers, in their first three years of the profession, indicated the lowest level of intentions to remain long term. It is well-documented that teaching has a traditionally high rate of attrition particularly among beginning teachers in their first five years (Smith & Ingersoll, 2004; Goldring et al., 2014; Redding & Henry, 2019). Our results support these findings yet show that in the first three years may be when the seed of intention to leave is planted. These initial years are a sensitive time

period for teachers to develop adaptive capacities and learn how to access resources to feel professionally successful and satisfied in the education system.

Our findings indicated that once teachers are assigned their own classroom as novice teachers, their intentions to remain decreased. The complexities of teaching, coupled with navigating working conditions and escalating expectations to make sure every student succeeds, can be exhausting for some teachers (Audrain et al., 2022). First-year teachers were held to the same standards and expectations as experienced teachers, yet early career teachers had not yet likely had the time to accumulate feelings of professional accomplishments or develop collegial relationships (Rumschlag, 2017). Although teaching can be solitary within the classroom (Trikoilis & Papanastasiou, 2020), there is often support from peers in the school. Therefore, because early career teachers can easily burn-out and develop negative feelings that may have been exacerbated by the pandemic as teachers were isolated from their peers, it is important for educational systems to acknowledge how to support these early career teachers (Gavish & Friedman, 2010).

Our survey population was representative of NSF Noyce Scholars who received funding to teach in STEM classrooms in districts with high needs schools. As a condition of the funding, scholarship recipients promise to serve one year in the STEM classroom for each semester of funding with a maximum of a four-year commitment. For these reasons, the participants who were novice and early career teachers were likely to report remaining in education. This was not surprising to us because of the careful selection process and professional development experiences provided by many Noyce programs (e.g., Grillo & Kier, 2021).

Using the focus group participants as a sample population, teachers indicated their intentions to stay, move, or leave. Of interest to us were the motivations influencing teachers'

intentions by years of experience. Preservice teacher's intentions were influenced by a combination of their perceptions of internal capacities such as growth in teaching competence and external environmental factors such as being hired at a school. Preservice stayers perceived external capacities as the strongest factor holding them in place while movers and leavers perceived external limitations pushing them out of their current location. Novice teachers' intentions about their professional plans were influenced exclusively by their internal (i.e., personal) contexts. Where novice stayers perceived internal capacities, movers and leavers perceived internal limitations. For early career teachers, perceived motivations varied for each intention. Stayers reported internal and external capacities and limitations as influencing their intentions. Having been a part of the education system for more than three years, they are more informed about how schools can function and the agency they have in the classroom. They are able to draw on adaptive capacities to navigate the education system using all aspects of their personal and environmental contexts to influence their intended behaviors. Early career movers and leavers perceived external limitations at motivating their decisions. Master teachers perceived internal capacities as the drivers of their intentions to stay or move such as self-efficacy and the belief in teaching as a way to support the community.

Several teachers across professional levels spoke about their fortitude to stay in the classroom whether in the same location or moving to a new school stemming from being optimistic. Although this was not the focus of the current paper, it is being explored in another study and provides opportunities to better understand internal and external variables that shape teachers' adaptive capacities. Other studies of teacher persistence in the profession have highlighted the important personal attribute and attitude around hope (Bullough & Hall-Kenyon, 2011; Mansfield et al., 2014).

Implications

The global spread of COVID-19 virus created an unexpected disturbance leading to rapid reorganization of education systems at all levels. In response to the COVID-19 pandemic, American public schools were quick to address students' needs and establish student support systems. Based on our findings, the top concern of schools and districts was to establish routines for the continuation of instructional delivery remotely which included both paper packet pick-up/drop-off or technology devices and internet connections so that teachers and students could meet virtually. Additionally, the National School Lunch Program provides low-cost or free nutritious meals to 29.7 million children daily (Tichen, 2019). Plans to continue the distribution of food to families in need were also of high importance. Once teachers were able to reconnect with their students, they attended to student social and emotional health, as well as intellectual growth. Reorganization to return education to “normal” was the top priority of the system.

The multiple levels that make up education systems ranging from federal systems at the largest organizing level, moving to smaller system organization at the state, district, and eventually school level all had to reorganize, rethink, and replan for the new school year. At the school level, individual teachers were managing their personal reorganization within the context of their school and district structures. With the many demands placed on teachers, especially for novice teachers on whom are placed the same high expectations as experienced teachers (Borman & Dowlin, 2008), little attention was paid by schools and school districts to influence teacher's professional intentions to remain in the teaching profession based on participant responses. This is concerning since teacher well-being and mental health is a factor connected to student success (Briner & Dewberry, 2007; Gray et al., 2017). When high quality STEM teachers decide to leave the educational system altogether, it adds to the stress of teacher shortages in the

US, especially communities vulnerable to being underfunded and under-resourced (Ingersoll, 2003; Jacobs, 2007).

Teacher educators and school administrators benefit from understanding the internal and external capacities and limitations influencing teachers intentions by (1) helping teachers develop their personal knowledge and skills for use in the classroom especially in light of the national shortage of STEM teachers in high-needs districts and (2) develop proactive plans for responding to unexpected crises on large scales (e.g., COVID-19 pandemic), as well as those limited to a particular region (e.g., natural disaster). These adaptive plans should include responses that go beyond a focus of continuing instructional delivery and safety to support student learning to also include support structures for teachers. The internal capacities of teachers will keep them teaching in the short term as we found in our surveys and interviews. Teachers persist for the long term when they feel connected to and supported by their school and are given opportunities to flourish (Grillo & Kier, 2021). Teachers whose intentions are to persist in the classroom, perceive that their personal capacities play a role in their professional feelings of success thereby connecting them to the education system. When the actors in a system remain consistent, the system is more likely to be resilient.

Literature cited

- Audrain, R. L., Weinberg, A. E., Bennett, A., O'Reilly, J., & Basile, C. G. (2022). Ambitious and sustainable post-pandemic workplace design for teachers: A portrait of the Arizona teacher workforce. In *Primary and Secondary Education During Covid-19* (pp. 353-381). Springer, Cham.
- Balgopal, M. M. (2020). STEM teacher agency: A case study of initiating and implementing curricular reform. *Science Education*, 104(4), 762-785.
- Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychological Review*, 84(2), 191.
- Bandura, A. (1989). Human agency in social cognitive theory. *American Psychologist*, 44(9), 1175.

- Barrett, J., Jones, G., Mooney, E., Thornton, C., Cady, J., Guinee, P., & Olson, J. (2002). Working with novice teachers: Challenges for professional development. *Mathematics Teacher Education and Development*, 4(2002), 15-27.
- Berkes, F., Folke, C., & Colding, J. (1998). *Linking social and ecological systems : management practices and social mechanisms for building resilience*. Cambridge, U.K.: Cambridge University Press.
- Bobbitt, S. A, Leich, M. C.. Whitener, S. D., & Lynch, H. R. (1994). *Characteristics of stayers, movers, and leavers: Results from the Teacher Follow-up Survey: 1991-92*. Washington, DC: National Center for Education Statistics.
- Borman, G. D., & Dowling, N. M. (2008). Teacher attrition and retention: A meta-analytic and narrative review of the research. *Review of Educational Research*, 78(3), 367-409.
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77-101.
- Briner, R., & Dewberry, C. (2007). *Staff well-being is key to school success*. London, U.K.: Worklife Support Ltd/Hamilton House.
- Bullough, R.V., & Hall-Kenyon, K.M. (2011). The call to teach and teacher hopefulness. *Teacher Development*, 15(2), 127-140.
- Burkman, A. (2012). Preparing novice teachers for success in elementary classrooms through professional development. *Delta Kappa Gamma Bulletin*, 78(3), 23-33..
- Carver-Thomas, D., & Darling-Hammond, L. (2017). *Teacher Turnover: Why It Matters and What We Can Do about It*. Palo Alto, CA: Learning Policy Institute.
- Chiong, C., Menzies, L., & Parameshwaran, M. (2017). Why do long-serving teachers stay in the teaching profession? Analysing the motivations of teachers with 10 or more years' experience in England. *British Educational Research Journal*, 43(6), 1083-1110.
- Creswell, J. W. (2021). *A concise introduction to mixed methods research*. SAGE publications.
- Day, C., & Gu, Q. (2013). *Resilient teachers, resilient schools: Building and sustaining quality in testing times*. Abingdon, U.K.: Routledge.
- Dedoose Version **9.0. (2021)**. Web application for managing, analyzing, and presenting qualitative and mixed method research data . Los Angeles, CA: SocioCultural Research Consultants, LLC www.dedoose.com
- Edwards, A. (2015). Recognizing and realizing teachers' professional agency. *Teachers and Teaching*, 21(6), 779-784.

- Ehren, M., Madrid, R., Romiti, S., Armstrong, P. W., Fisher, P., & McWhorter, D. L. (2021). Teaching in the COVID-19 era: Understanding the opportunities and barriers for teacher agency. *Perspectives in Education*, 39(1), 61-76.
- Fereday, J., & Muir-Cochrane, E. (2006). Demonstrating rigor using thematic analysis: A hybrid approach of inductive and deductive coding and theme development. *International Journal of Qualitative Methods*, 5(1), 80-92.
- Fullan, M., & Loubser, J. J. (1972). Education and adaptive capacity. *Sociology of Education*, 45(3), 271-287.
- Gallopín, G. C. (2006). Linkages between vulnerability, resilience, and adaptive capacity. *Global Environmental Change*, 16(3), 293-303.
- Gavish, B., & Friedman, I. A. (2010). Novice teachers' experience of teaching: A dynamic aspect of burnout. *Social Psychology of Education*, 13(2), 141-167.
- Goldring, R., Taie, S., & Riddles, M. (2014). *Teacher attrition and mobility: Results from the 2012–13 teacher follow-up survey. First look. NCES 2014–077*. Washington, D.C.: National Center for Education Statistics.
- Gray, C., Wilcox, G., & Nordstokke, D. (2017). Teacher mental health, school climate, inclusive education and student learning: A review. *Canadian Psychology/psychologie canadienne*, 58(3), 203.
- Grillo, M., & Kier, M. (2021). Why do they stay? An exploratory analysis of identities and commitment factors associated with teaching retention in high-need school contexts. *Teaching and Teacher Education*, 105, 103423.
- Gubler, M., Biemann, T., & Herzog, S. (2017). An apple doesn't fall far from the tree—Or does it? Occupational inheritance and teachers' career patterns. *Journal of Vocational Behavior*, 100, 1-14.
- Gudmundsdottir, G. B., & Hathaway, D. M. (2020). “We always make it work”: Teachers’ agency in the time of crisis. *Journal of Technology and Teacher Education*, 28(2), 239-250.
- Hartshorne, R., Baumgartner, E., Kaplan-Rakowski, R., Mouza, C., & Ferdig, R. E. (2020). Special issue editorial: *Preservice and inservice professional development during the COVID-19 pandemic*. *Journal of Technology and Teacher Education*, 28(2), 137-147.
- Hodges, C. B., Moore, S., Lockee, B. B., Trust, T., & Bond, M. A. (2020). *The difference between emergency remote teaching and online learning*. The Edu-CAUSE Review.
- Huck, C., & Zhang, J. (2021). Effects of the COVID-19 Pandemic on K-12 Education: A Systematic Literature Review. *New Waves-Educational Research and Development Journal*, 24(1), 53-84.

- Ingersoll, R. M. (2003). *Is there really a teacher shortage?* Seattle: University of Washington, Center for the Study of Teaching and Policy.
- Jacob, B. A. (2007). The challenges of staffing urban schools with effective teachers. *The Future of Children*, 129-153.
- Keshavarz, N., Nutbeam, D., Rowling, L., & Khavarpour, F. (2010). Schools as social complex adaptive systems: a new way to understand the challenges of introducing the health promoting schools concept. *Social Science & Medicine*, 70(10), 1467-1474.
- Lockwood, M., Raymond, C. M., Oczkowski, E., & Morrison, M. (2015). Measuring the dimensions of adaptive capacity: a psychometric approach. *Ecology and Society*, 20(1).
- Luekens, M. T. (2004). *Teacher attrition and mobility: Results from the teacher follow-up survey, 2000-01*. Washington, D.C.: National Center for Education Statistics.
- Malkus, N., & Christensen, C. (2020). *School District Responses to the COVID-19 Pandemic: Round 3, Plans for a Remote Finish*. American Enterprise Institute.
- Mansfield, C., Beltman, S., & Price, A. (2014). 'I'm coming back again!' The resilience process of early career teachers. *Teachers and Teaching*, 20(5), 547-567.
- Martin, T., & Thomson, I. (2018). Adaptive capacity in the Pacific region: a study of continuous professional development for in-service teachers in Kiribati. *Asia-Pacific Journal of Teacher Education*, 46(1), 6-21.
- McLennan, B., McIlveen, P., & Perera, H. N. (2017). Pre-service teachers' self-efficacy mediates the relationship between career adaptability and career optimism. *Teaching and Teacher Education*, 63, 176-185.
- Nelson, D. R. (2011). Adaptation and resilience: responding to a changing climate. *Wiley Interdisciplinary Reviews: Climate Change*, 2(1), 113-120.
- Nolan, A., & Molla, T. (2017). Teacher confidence and professional capital. *Teaching and Teacher Education*, 62, 10-18.
- Olinger Steeves, R. M., Metallo, S. A., Byrd, S. M., Erickson, M. R., & Gresham, F. M. (2017). Crisis preparedness in schools: Evaluating staff perspectives and providing recommendations for best practice. *Psychology in the Schools*, 54(6), 563-580.
- Priestley, M., Biesta, G.J.J. & Robinson, S. (2015). Teacher agency: What is it and why does it matter? In R. Kneyber & J. Evers (eds.), *Flip the System: Changing Education from the Bottom Up* (pp. 134-148). London, U.K.: Routledge.
- Redding, C., & Henry, G. T. (2019). Leaving school early: An examination of novice teachers' within-and end-of-year turnover. *American Educational Research Journal*, 56(1), 204-236.

- Reimers, F. M. (2022). Learning from a pandemic. The impact of COVID-19 on education around the world. In *Primary and Secondary Education During Covid-19* (pp. 1-37). Cham, Switzerland: Springer.
- Rivkin, S., Hanushek, E., & Kain, J. (2005). Teachers, schools and academic achievement. *Econometrica*, 73, 417–458.
- Rumschlag, K. E. (2017). Teacher burnout: A quantitative analysis of emotional exhaustion, personal accomplishment, and depersonalization. *International Management Review*, 13(1), 22-36.
- Skaalvik, E. M., & Skaalvik, S. (2011). Teacher job satisfaction and motivation to leave the teaching profession: Relations with school context, feeling of belonging, and emotional exhaustion. *Teaching and Teacher Education*, 27(6), 1029-1038.
- Smith, T. M., & Ingersoll, R. M. (2004). What are the effects of induction and mentoring on beginning teacher turnover? *American Educational Research Journal*, 41(3), 681-714.
- Stites, M. L., Rakes, C. R., Noggle, A. K., & Shah, S. (2019). Preservice teacher perceptions of preparedness to teach in inclusive settings as an indicator of teacher preparation program effectiveness. *UMBC Faculty Collection*.
- Tiehen, L. (2019). The food assistance landscape: Fiscal year 2019 annual report, Economic Research Service, Economic Information Bulletin Number EIB-2018. Washington: US Department of Agriculture.
- Toom, A., Pyhältö, K., & Rust, F. O. C. (2015). Teachers' professional agency in contradictory times. *Teachers and Teaching*, 21(6), 615-623.
- Trikoilis, D., & Papanastasiou, E. C. (2020). The potential of research for professional development in isolated settings during the covid-19 crisis and beyond. *Journal of Technology and Teacher Education*, 28(2), 295-300.
- Trust, T., & Whalen, J. (2021). Emergency remote teaching with technology during the COVID-19 pandemic: using the whole teacher lens to examine educator's experiences and insights. *Educational Media International*, 58, 1-16.
- Wang, Y., Ko, P., & Law, N. (2020). Building social capital for constructive adaptive capacity under social stress. *Journal of Professional Capital and Community*, 5(3/4), 247-253
- Wright, D. S., Balgopal, M. M., Sample McMeeking, L. B., & Weinberg, A. E. (2019). Developing resilient K-12 STEM teachers. *Advances in Developing Human Resources*, 21(1), 16-34.

- Wright, D. S., Crooks, K. R., Hunter, D. O., Krumm, C. E., & Balgopal, M. M. (2021). Middle school science teachers' agency to implement place-based education curricula about local wildlife. *Environmental Education Research*, 27(10), 1519-1537.
- Woodbury, S., & Gess-Newsome, J. (2002). Overcoming the paradox of change without difference: A model of change in the arena of fundamental school reform. *Educational Policy*, 16(5), 763-782.
- Zieher, A. K., Cipriano, C., Meyer, J. L., & Strambler, M. J. (2021). Educators' implementation and use of social and emotional learning early in the COVID-19 pandemic. *School Psychology*, 36(5), 388.

CHAPTER 6

CONCLUSION

This dissertation began with investigating the role of **place** in K-12 science education in advancing civic environmental literacy (EL). The journey ended with understanding teachers' **agency** to use **place**.

I approached this research with the aim of combining adaptive capacity frameworks used in natural sciences with social cognitive theory in social sciences to examine the experiences of teachers who use place-based education (PBE) to increase student EL. Adaptive capacity frameworks serve as a foundation for describing the education system's responses to disturbance while social cognitive theory describes teachers' behaviors as they are influenced by personal and professional contexts. Agency connects the teacher's behavior to the system. Teachers who demonstrate agency are able to draw on past experiences to enact current behaviors while also projecting how the past and present influence the future. Simultaneously, teachers are considering the personal and professional contexts that influence their thinking about what behaviors to enact. Hence, this dissertation advances the research on the complexity of factors that affect teacher agency.

The **agentic teacher** has the ability to act in ways that support the use of PBE curriculum (Paper 1) and professional decisions to remain in the classroom (Papers 2 and 3). Sometimes, using **place** (i.e., local cultural, social, and physical capital) can affect teachers' **agency** to remain in the school (Paper 2). As I reflect on my classroom observation experiences where I was startled by the removal of people from the environment in lessons, I realize that research on

environmental education (EE) often does the same thing; it removes teacher agency from the push to increase EE in the classroom. Teachers should be at the center of PBE from curriculum design to implementation to facilitating civic engagement. We cannot study the impacts of PBE on students without studying the teacher as well.

Future Research Directions

This dissertation work began as an examination of the experiences of teachers as they used place in their curriculum. The work expanded to examining the influence of place (and context) on teachers' decisions to remain in education. I chose to focus on these issues based on my own professional experiences prior to returning to graduate studies. My positionality influenced my decisions to orient this research around secondary science teachers. My perspectives on science education are shaped by my twenty-four years in public schools as a middle and high school science teacher, an elementary science instructional coach, and school district level science curriculum facilitator. I have the ability to draw on my own teaching experiences to shape my current and future research. I realized that as I investigated teachers' agency, I investigated my own agency as an ecologist. Through a "human environmental interactions" lens, I expanded my understanding of how ecology is studied to include valuing how people interpret environmental issues and make decisions to manage these. As I move forward as an educator and ecologist using PBE to drive my work, I plan to view the classroom and the environment from multiple perspectives providing insights on the interconnectedness of people with the natural world. I also plan to collaborate with ecologists and environmental scientists who endeavor to educate, motivate, and support people in learning about environmental issues and actions.

PBE provides a rich landscape to continue research on the ways teacher's personal experiences intersect with their professional actions. What this dissertation illuminates is that, even if teachers have resources and opportunities (e.g., PBE curriculum or access to local outdoor or cultural resources), they do not always integrate these into their curricula. Why is that? Teachers are not alone in the classroom. They are there because of students, but they are affected by a larger socio-economic system. They must respond to parents, administrators, peers, community members, and educational policies. Teachers who feel empowered and prepared to test new curricula often do so, but there are many more teachers who are not well-positioned (or not rewarded) for being risk-taking. This dissertation demonstrated how teacher agency explains the choices teachers make when acknowledging that place in their curricula and their professional choices to remain or leave a school.

The studies in this dissertation highlighted many opportunities for further studies. One of the aspects of PBE is connecting teachers with local experts. Although many PBE studies describe how local experts are invited by teachers into their classrooms (e.g., Cruz et al., 2018; Howley et al., 2011; Takano et al., 2009), or how local experts contact teachers (e.g., Lane et al., 2018; Krasney & Tidball, 2009), the impact of these partnerships are rarely examined. I believe that this is an important gap in our understanding of PBE and by studying partnerships, environmental educators can more effectively increase both students and teachers' respective EL.

Another needed area of study is around the relationship between PBE and civic engagement. Although one of the goals of PBE is to promote civic literacy, publications around this competency tend to be situated in social studies classrooms (e.g., Stafaniak et al., 2017). There is a need for science education research to focus on social justice and civic engagement (Calabrese Barton & Yang, 2000; Rudolph & Horibe, 2016). Related area of research that

warrants further study is examining students' agency in formal classrooms to be more civically engaged (Calabrese Barton & Tan, 2010). Angela Calabrese Barton is an expert who writes about environmental education and its relationship to social justice-oriented behaviors of youth, but her studies are most often centered in informal spaces (afterschool programs, clubs, and community centers). There is a need to be informed by Calabrese Barton's work and to explore how formal K-12 classrooms can be spaces that inspire youth to be active change agents in promoting pro-environmental behaviors (Kollmus & Agyeman, 2002). In other words, there is a need for more studies to examine how students achieve agency when learning science in locally and culturally relevant contexts, and how this may or may not spark their interest in being change agents in their own communities. Although it may be difficult to measure changes in behaviors at a large scale, it is still critical information to gather and analyze. Using a case study approach, which I learned through Study 2, I am well positioned to continue my studies of PBE by following a few teachers and their students to determine what influences their decisions to change behaviors or not.

Finally, knowing that teachers' ideas about teaching and increasing students' EL is affected by their sense of curriculum ownership (Wright et al., 2021; Balgopal, 2020), there is a need for more studies that describe how teachers identify meaningful local issues for their students to investigate. Teachers have access to many resources, but it is not clear how they leverage these for their coursework. Is it a methodical or serendipitous process? Do teachers use resources provided to them by district curriculum facilitators, a role I used to have, or do they seek their own resources? Which resources are they more likely to use? And, which teachers are better able to follow through with teaching PBE - are these biology, chemistry, physics, or Earth

system science teachers. Knowing this information will inform ecologists and environmental scientists who wish to partner with and/or support K-12 teachers.

In summary, PBE connects people to places, and, at the very least, it reminds people of their connections to places (Campbell, 2006). As people connect to places, they develop a “sense of place” often leading to behaviors that maintain the health and beauty of the place. Each of the studies in this dissertation included aspects of environmental issues that affected the places study participants occupied. Study 1 was inspired by teachers teaching about human-wildlife interactions, Study 2 was a description of changing rural socioecological systems and teachers’ professional decisions, and Study 3 was designed in response to a global pandemic (pathogen evolution and transmission) impacting public health and social systems, including schools. Understanding this connection to place and people’s motivations for taking action (through their agency) is essential as communities take action to manage small and large scale ecological disturbances for the foreseeable future.

Literature cited

- Balgopal, M. M. (2020). STEM teacher agency: A case study of initiating and implementing curricular reform. *Science Education*, 104(4), 762-785.
- Calabrese Barton, A., & Tan, E. (2010). We be burnin'! Agency, identity, and science learning. *The Journal of the Learning Sciences*, 19(2), 187-229.
- Calabrese Barton, A., & Yang, K. (2000). The culture of power and science education: Learning from Miguel. *Journal of Research in Science Teaching*, 37(8), 871-889.
- Campbell, S. (2006). Layers of place. *Interdisciplinary Studies in Literature and Environment*, 13(2), 179-183.
- Cruz, A. R., Selby, S. T., & Durham, W. H. (2018). Place-based education for environmental behavior: a ‘funds of knowledge’ and social capital approach. *Environmental Education Research*, 24(5), 627-647.
- Howley, A., Howley, M., Camper, C., & Perko, H. (2011). Place-based education at island community school. *The Journal of Environmental Education*, 42(4), 216-236.

- Kollmuss, A., & Agyeman, J. (2002). Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behavior?. *Environmental Education Research*, 8(3), 239-260.
- Krasny, M. E., & Tidball, K. G. (2009). Community gardens as contexts for science, stewardship, and civic action learning. *Cities and the Environment (CATE)*, 2(1), 8.
- Lane, J. F., Ateşkan, A., & Dulun, Ö. (2018). Turkish teachers' use of the outdoors as a teaching resource: Perceived facilitators and obstacles. *Applied Environmental Education & Communication*, 17(1), 14-28.
- Stefaniak, A., Bilewicz, M., & Lewicka, M. (2017). The merits of teaching local history: Increased place attachment enhances civic engagement and social trust. *Journal of Environmental Psychology*, 51, 217-225.
- Takano, T., Higgins, P., & McLaughlin, P. (2009). Connecting with place: Implications of integrating cultural values into the school curriculum in Alaska. *Environmental Education Research*, 15(3), 343-370.
- Wright, D. S., Crooks, K. R., Hunter, D. O., Krumm, C. E., & Balgopal, M. M. (2021). Middle school science teachers' agency to implement place-based education curricula about local wildlife. *Environmental Education Research*, 27(10), 1519-1537.

APPENDIX A

ACADEMIC STANDARDS ALIGNMENT

Next Generation Science Performance Expectations for Middle School Life Science addressed by these lessons included Disciplinary Core Idea for MS-LS2 Ecosystems:

Interactions, Energy, and Dynamics (NGSS Lead States, 2013):

MS-LS2-1 Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem

MS-LS2-2 Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems

MS-LS2-3 Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem

MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations

MS-LS2-5 Evaluate competing design solutions for maintaining biodiversity and ecosystem services

Although the state in which this study was conducted had not yet adopted NGSS when data were collected, the current state standards have been evaluated by Summers et al. (2019) as exemplary particularly in the development of the nature of science. Science inquiry and science process skills are embedded within the science content.

APPENDIX B

UNIT OUTLINE AND SAMPLE LESSON PLAN

Using the local environment to address middle school ecology concepts

Desired Results		
ESTABLISHED GOALS Disciplinary Core Idea for MS-LS2 Ecosystems: Interactions, Energy, and Dynamics (NGSS Lead States, 2013): MS-LS2-1 Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem MS-LS2-2 Construct an explanations that predicts patterns of interactions among organisms across multiple ecosystems MS-LS2-3 Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem	<i>Transfer</i>	
	<i>Students will be able to independently use their learning to...</i> Scientific Knowledge Assumes an Order and Consistency in Natural Systems. Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. Science Addresses Questions About the Natural and Material World. Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.	
	<i>Meaning</i>	
	UNDERSTANDINGS <i>Students will understand that...</i> Ecosystems are dynamic in nature: their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.	ESSENTIAL QUESTIONS How do organisms interact with the living and nonliving environments to obtain matter and energy? How do matter and energy move through an ecosystem?

<p>MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations</p> <p>MS-LS2-5 Evaluate competing design solutions for maintaining biodiversity and ecosystem services</p>		What happens to ecosystems when the environment changes?
	Acquisition	
	<p><i>Students will know...</i></p> <p>Organisms and populations of organisms are dependent on their environmental interactions both with other living things and with nonliving factors.</p> <p>Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem.</p> <p>Ecosystems are sustained by the continuous flow of energy.</p>	<p><i>Students will be skilled at...</i></p> <p>Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem</p> <p>Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.</p> <p>Evaluate competing design solutions for maintaining biodiversity and ecosystem services.</p> <p>Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.</p>
Learning Plan		
<p><i>Adapt these lessons to your local wildlife. The examples show urban wildlife found in [city, state].</i></p> <p>Ecological Phenomena to Engage Students</p> <ol style="list-style-type: none"> 1. Organisms interact in ways that influence their abundance. 2. Ecosystems are organized into webs of interactions. 3. Human populations have an outsized role in competing with, preying upon, and helping other organisms. 4. Ecosystems provide essential services to human populations. 		

Lesson: What can we learn from a photo?

Lesson: Nature observations

- Introduction to nature journaling
- Sense of wonder
- Sense of sound
- Sense of touch and sight

Lesson: Wildlife signs

Lesson: Photographic data analysis

Lesson: Food chains

- Predator/prey game
- Energy pyramid scavenger hunt

Lesson: Human impacts on ecological systems

Format adapted from Wiggins & McTighe, 2011

What can we learn from a photo?

Time: 90 minutes

Grade: 6-8

Background:

Biodiversity, the variety of life forms and their ecosystems, is decreasing. Planet Earth is experiencing an anthropogenically driven biological diversity loss of uncomparable proportions (Dirzo, et al., 2104). It is estimated that 11,000-58,0000 species are being lost annually, and as the total number of species on Earth remains an estimate, this guess could be a conservative number. The primary threat to biodiversity loss is habitat destruction, however, resource overexploitation, species introduction, pollution, and climate change are also contributing factors (Hausmann, et al., 2016). Biodiversity is a good thing, a thing that should be valued as it offers several ecological benefits, services, and functions. Thus, the decline in biodiversity poses severe risks and impacts to the environment. Some of the ecosystem services impacted by biodiversity include water quality, insect pollination, pest management, nutrient cycling, decomposition, carbon sequestration, and human health (Dirzo, et al., 2014). In addition to the intrinsic value of nature and biodiversity, there are also several economic benefits and values associated to the ecosystem services of biodiversity (Daily, et al., 2009). Insects play a primary role in global food production as they pollinate 75% of the global food crop and comprise 10% of the economic value of the entire world food supply (Dirzo, et al., 2014). Carbon sequestration and storage, which is becoming increasingly important with global climate change, is another ecosystem service directly linked to biodiversity (De Beenhouwer, et al., 2016). In addition to the economic benefits to ecological services, biodiversity also offers economic benefits associated with human quality of life. According to research, spending time in nature offers many health benefits including faster recovery from stress, the promotion of higher-order cognitive functioning, an increase in observation and reasoning abilities, and intellectual and emotional development in children (Miller, 2005). In addition to enhancing quality of life, direct contact with nature has been shown to increase physical, mental, and psychological well being (Hausmann, et al., 2016). All of these human benefits translate into economic value in the form of the willingness-to-pay theory (Clayton & Myers, 2009). The basis of this theory is that nature has concrete value to people and these benefits offset potential health related issues later in life.

It is the goal of this lesson to create personal connections for students with wildlife species in their own backyard to motivate students to protect biodiversity (Miller, 20005). In a world facing the sixth mass extinction, and the first human triggered one, wildlife conservationists are preaching the doom and gloom of the future. However, despair only leads to lack of action. Research indicates that by introducing children, at too young of an age, to daunting global issues, such as climate change, only instills helpless and hopeless rather than inspiration and motivation (Sobel, 2007). Instead, conservationists need to advocate for hope (Swaigood & Sheppard, 2009). Rituals, opportunities that provide a regular routine of interacting with nature, and projects that inspire hope in young generations need to be offered

and incorporated into curriculum. Sobel (2007) recommends opportunities to interact with nature begin with the youngest generations, and these opportunities need to address environmental issues constructively and optimistically. There is a fine line between hope and reality; it is the goal of this lesson to cultivate hope and inspire action to create a new reality for the future of biodiversity on planet Earth.

Learning Targets:

- Students will be able to explain why biodiversity is good and valuable to ecosystem health, function, and sustainability
- Students will develop a personal connection to wildlife species in their own backyard.
- Students will be inspired to take a proactive approach to protecting biodiversity in the future.

NGSS Disciplinary Core Idea for MS-LS2 Ecosystems: Interactions, Energy, and Dynamics:

- MS-LS2-1 Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem
- MS-LS2-2 Construct an explanations that predicts patterns of interactions among organisms across multiple ecosystems
- MS-LS2-5 Evaluate competing design solutions for maintaining biodiversity and ecosystem services

Materials:

- Nature journals
- Writing utensils
- Printed wildlife camera photos from school camera
- Activity sheets

Engage

- Ask students: what is biodiversity?
 - a. Generate discussion
 - b. Define biodiversity: the variety of all life forms and their ecosystems
 - Ask students: what does a biologically diverse ecosystem looks like?

- Ask students: how many species do you think there are on Earth?
 - a. Write estimate in journal.
 - b. Present stats
 - It is estimated that there are between **3 - 30 million species** on Earth, with a few studies predicting that there may be over **100 million species** on Earth!
 - Currently, we have identified only **1.7 million species**, so we have a long way to go before we can come close to figuring out how many species are on Earth!
 - c. Ask students: why does the estimate vary so much? Why is it an estimate? Why don't we know for sure?
- Ask students: Why is biodiversity a good thing? Why is it important? Why should we protect it?
 - Students will write down ideas in their journal.
 - Generate discussion - ask for student ideas
 - Food and resources
 - Medical discoveries - diseases
 - Ecological services- pollination, food, oxygen, nutrients
 - Adapt - disturbances such as fires and floods.
 - Genetic diversity - prevents disease spread and help species adapt
 - Beauty and wonder
- Transition into next activity: remind students of wildlife camera project.
 - a. Today we will discover what we can learn from the photos and why it is important

Wildlife Photo Activity

- Give one photo to each table
- Pass out activity sheets to each student

- Students will follow directions on activity sheet
 - Students will work independently first - silently look at photo (3-5 min.)
 - Students will discuss the photo with their table and add observations to their own activity sheet (3-5 min.)
- Teacher will bring class back together to share observations. Ask each group the following questions:
 - What did you notice first?
 - What animal(s) were in your photo?
 - What other observations did you have?
 - What are some of your wonderings? (I wonder why...?)
- Bring class together and ask: what can we learn from these photos?
 - Generate class discussion - these photos provide insight into the secret lives of animals and allows us to study biodiversity in a non-invasive way.
- Trail cameras are used to study the biodiversity in an area. These photos provide insight into wildlife patterns in a changing environment. We will use this study to make a personal connection to biodiversity in our own backyard.
 - Create list of ideas/concepts/information we can learn from photos
 - Show wildlife photos (and pass around for students to see) that depict each of the following:
 - Behavior
 - Population Estimate
 - Individual Organism Identification
 - Prey Species
 - Assess health of population - are wildlife species reproducing?
 - Species Diversity

Extensions

- Take students outside to the area around the school or camera, if already set up.
- Have students sit quietly for 10 minutes and create a species inventory prediction list.
 - Challenge students to include all animal groups.
 - What animals do they expect to see on the camera?
- The [Non-profit Organization] project has wildlife trail cameras in urban areas around schools and in natural areas. Ask students to reflect on the following question and write a response in their journal:
 - What species might you see in the natural areas that you wouldn't see around the school and vice versa?

Student Instructions

Urban Wildlife Photo Activity

Directions:

1. Without talking, look at the picture on your table.
2. Take a few moments to notice all of the details in the picture.
3. Answer the following prompts....

The animal(s) in this photo:

The date and time of this photo:

Weather:

Other observations:

-
-
-
-
-

General wonderings:

- I wonder why....?
- I wonder why....?
- I wonder why....?

Think, pair, share:

1. Discuss the photo with your tablemates.
2. Compare observations and questions.
3. Add to your answers in a different color to incorporate all thoughts at your table

APPENDIX C

PARTICIPANT DEMOGRAPHICS

Table C1
Participant Demographics

<u>Teacher</u>	<u>Years Teaching</u>	<u>Grade Level</u>	<u>School Focus</u>	<u>Avg. Class Size</u>	<u>Class Length</u>
Beth	8	7th	Avid; Traditional	32	80 min. every other day
Jessica	12	6th, 7th	Traditional	26	80 min. every other day
Michelle	28	6th	International Baccalaureate	28	80 min. TWThF; 45 min. M
Cathy	6	6th	International Baccalaureate	35	80 min. every other day
Ronald	12	8th	International Baccalaureate	28	55 min. daily
JoAnne	2	6th, 7th	Expeditionary	24	70 min. MTThF; 55 min. W
Anna	6	6th, 7th, 8th	Hybrid online and in-person	15	50 min. 2X/week
CiCi	11	6th	STEM	30	80 min. every day for 1 semester
Melissa	21	6th	STEM	30	80 min. every day for 1 semester
Meghan	4	7th	Avid; Traditional	30	77 min. every other day
Teresa	1	6th, 7th, 8th	Waldorf	10	50 min. once per week for 1 semester

APPENDIX D

INTERVIEW PROTOCOL

Semi-structured interview questions

Initial interview

Introduction Script:

Thank you for volunteering to speak with us today about your experiences using local urban wildlife to teach ecology concepts. The interview should take about 60 minutes to complete. Please know that all identifying information will be removed from all analyses and that only the research team will have access to the data (audio-recordings and transcripts). Please know that there are no right or wrong answers to these questions, we are interested in your opinions and your experiences. If you wish to decline to answer, you may do so. If you need to take a break at any time, please let us know. Audio-recording will allow us to capture your thoughts. Before we begin, do we have your permission to audio-record our conversation? Do you have any questions before we begin the interview?

Information About You

- Name
- Current school
- How many years have you been at this school?
- How many years have you been teaching total?
- What are the current classes & grades that you teach?

Information About Your School

- Describe the structures that define your school, i.e. class length, avg. class size, scheduling for students, anything unique about your school

Curriculum Decisions

- How do you decide what curriculum to use in your classroom?

Wildlife Camera Use or Intent to Use

- Describe how you have been using the wildlife camera trap as part of your curriculum.
- What benefits have you experienced by using the wildlife camera trap?
- What are your perceptions of student engagement with the camera and data?
- What barriers have you experienced in using the wildlife camera?
- How have you addressed these barriers?
- Describe your use of the pre-written curriculum provided with the camera.
- Describe how the lessons address your learning objectives for the life science standard (LS2.1)?
- What plans do you have for future use of the camera and/or written curriculum?

Semi-structured interview questions

Follow-up interview

Local environment

- How would you describe the area where your school's camera is located?
- Have you been able to take students to the camera location?
If so, describe the experience.
If not, what are the barriers?

Collaborations

- In what ways have you felt supported by [non-profit organization]?
- In what ways have you felt supported by your peers (i.e. other teachers participating in the camera trap project)?

Interdisciplinary connections

- In using the photographic data and accompanying curriculum, what connections have you been able to make to other content areas?

Pedagogy

- Describe how you have been using the wildlife camera trap as part of your curriculum.
- In what ways have you adapted the pre-written curriculum to meet your student population?
- Describe how the lessons address your learning objectives for life science standards?
- What benefits have you experienced by using the wildlife camera trap?
- What are your perceptions of student engagement with the camera and data?
- What barriers have you experienced in using the wildlife camera?
- How have you addressed these barriers?

Civic engagement

- What actions have your students expressed a desire to take or taken as a result of learning about local urban wildlife?

Future Use

- What plans do you have for future use of the camera and/or written curriculum?

APPENDIX E

CODING SCHEME

Table E1

Data analysis map: How open codes lead to selective codes

<u>Open Codes</u>	<u>Axial Codes</u>	<u>Selective Codes</u>
Personal background		
Professional background		
Feelings about nature	Reflective practice	
Empathy		
Sympathy		
		Agency
Goals for self		
Identity as teacher		
Identity as scientist	Reflexive practice	
Personal investment		
Comfort with uncertainty		
Environmental ethics		
Academic standards		
Use of camera traps		
Authentic data	Instructional context	
Assessment tools		
Curriculum design		
Curriculum materials		
		Alignment
Content delivery		
School structure	Classroom context	
Class structure		